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NA-72-7

THE DEVELOPMENT OF MOTION PICTURE MEASUREMENT INSTRUMENT FOR APTITUDE FOR  
AIR TRAFFIC CONTROL

E. P. Buckley, Tom Beebe

Final Report, January 1972, 37p.

(RD-71-106) (AD 735 942)

A motion picture test for aptitude for air traffic control was developed and pretested with 19 air traffic control specialists. The test was developed at the National Aviation Facilities Experimental Center (NAFEC) during this project for use in a project being conducted for Federal Aviation Administration by Education and Public Affairs (EPA). That project report will contain data on use of the test with a much larger sample. This report describes the test and gives estimates of reliability and validity as obtained from the administration of the test to the above-mentioned sample of 19 air traffic control specialists.

NA-72-8

ATC/CAS INTERFACE SIMULATION - EXPLORATORY PHASE

Gordon Jolitz

Interim Report, March 1972 173p.

(RD-72-10) (AD 739 369)

A dynamic simulation was conducted at the National Aviation Facilities Experimental Center to explore the nature of the interaction between the Air Traffic Control (ATC) system and a collision avoidance system (CAS). The simulated ATC environment was a high density terminal area which provided for simultaneous approaches to parallel runways. The CAS threat logic was modeled after a design which was developed by a technical working group under the auspices of the Air Transport Association. Threat evaluation and maneuver output of the CAS were based on measured range, range rate and altitude difference. The objective was to study the characteristics of ATC/ CAS interaction as a function (a) of the location of the CAS switchpoint from full system threat evaluation to landing mode; and (b) variations in controller technique. Results were reported in terms of (1) adjustments to controller techniques through the experimental conditions, (2) the effects on measures of ATC system performance, (3) the number and kind of the CAS output commands, and the concentration of certain of these in an area defined as the final approach zone, (4) the proportion of CAS commands requiring pilot response versus those requiring no response, (5) an analysis of climb/dive encounters, (6) an analysis of violations of ATC separation criteria with CAS involvement, and (7) controller reaction.

NA-72-10

EVALUATION OF THE NAS EN ROUTE STAGE A MODEL 3D, WEATHER AND FIXED MAP UNIT

Robert W. Delaney

Final Report, June 1972 130p.

(RD-72-52) (AD 746 511)

The first preproduction model of the Model 3D production weather equipment, identified as a Weather and Fixed Map Unit (WFMU) was installed at the Elwood, New Jersey, radar facility along with a modification to the Production Common Digitizer (PCD) for generating contours around weather clutter. The WFMU processed contours at two intensity levels at controlled maximum range and azimuth intervals which were formulated into weather map messages and transmitted over modems to the operational facility. Several technical and operational tests were performed to assure interface with the PCD and to verify conformance with the specification. Design changes were introduced to optimize the weather subsystem effectiveness. Calibration methods and trouble shooting aids were established for use by field personnel. It was concluded that the WFMU was capable of generating reliable contours around weather clutter and was not affected by aircraft signals. Log and MTI videos of 4.0 volts with a noise level adjusted to a nominal 0.75 ( $\pm 0.5$ ) volts mean peak were necessary to achieve clutter estimate calibration of weather contours. Effective control of weather map data rates was accomplished by a weather discrimination feature in the PCD and by a sampling arrangement in the WFMU that transmitted the contours at one-third the display resolution. It is recommended that WFMU transmission intervals for outer and inner contours be selected for display resolution of 2.8 and 0.7° respectively.

NA-72-11

EVALUATION OF STOL MODULAR INSTRUMENT LANDING SYSTEM (MODILS)

Glen D. Adams

Final Report, May 1972 53p.

(RD-74-2) (AD 743 555)

The FAA procured two modular instrument landing system (MODILS) ground stations for short take-off and landing (STOL) operational evaluation. MODILS operates at 5.2 GHz (C-band solid-state transmitter), providing localizer and glide slope signals, from a common site, for approach guidance to aircraft equipped with a MODILS receiver. Proportional guidance is provided from 3° to 12° elevation and above  $\pm 30^\circ$  in azimuth. The pilot may select his glide slope angle in increments of 0.1° and one of three localizer courses: parallel to runway centerline, 2° skew one side and 6° skew the other side. The pilot may also select his indicator sensitivities. An integral distance measuring equipment (DME) is included which provides readouts to 0.01 nmi. The system provides good quality guidance signals to adequately support Category I type (200-foot decision height) operations. The consistent DME operating range is about 5 nmi. The monitors are not of commissionable quality due to reliability and stability problems.

NA-72-12

OPERATIONAL EVALUATION OF AN INTERIM LOOP DISPLAY SYSTEM

Howard F. Slattery

Ward McCombs, Lt. Col., USAF

Final Report, April 1972 26p.

(RD-72-18) (AD 740 541)

An operational evaluation to determine the feasibility of using an interim loop display system to display surface traffic movements in blind spot areas was conducted at the J.F. Kennedy Airport. Specific objectives were to (1) determine the reliability of the system, (2) determine the operational utility of the displayed data, and (3) identify and document relevant technical and operational data to assist in determining future design requirements. The interim loop display system consisted of a logic unit, a display unit and a remote control box. A total of 28 magnetic induction loops was imbedded in the surface of the portion of the taxiway that was not visible from the tower. Loop sensors detected passage of vehicles and the information was displayed in the tower cab. It was concluded that the interim loop display system did not provide a reliable of aircraft or vehicular movement in the "blind spot" area at the J.F. Kennedy Airport. Many malfunctions of the display system were recorded during the evaluation period. Additionally, many intrusions by ground vehicles at unauthorized points caused erroneous indications on the display. The display system, in the opinion of the controllers, had little or no operational utility. The numerous intrusions created a lack of confidence in the system which contributed to this opinion.

NA-72-13

TEST AND EVALUATION OF CATEGORY III ILS GROUND GUIDANCE EQUIPMENT "STAN-38

GLIDE SLOPE TESTS AT NAFEC ON RUNWAY 4"

Edmund A. Zyzys

Final Report, September 1972 69p.

(RD-72-105) (AD 750 070)

A STAN-38 glide slope system in an M-array without clearance configuration was installed on runway 4 at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, under a joint U.S./FAA and U.K./DTI work agreement. The system was tested for conformance to ICAO Annex 10 Category III ILS specifications for system performance and stability and for monitor performance with amplitude and phase errors in the antenna system. The effects of prevailing weather conditions on the executive monitor system were recorded. It was concluded that the primary performance characteristics met ICAO specifications, and that the executive monitor system using specified alarm limits for the test provided satisfactory alarms during degraded performance conditions except in the dephased upper antenna fault condition.

NA-72-14

TEST AND EVALUATION OF CATEGORY III ILS GROUND GUIDANCE EQUIPMENT "STAN-37  
LOCALIZER TESTS AT NAFEC ON R/W-4"

Henry W. Kasper

Interim Report, May 1972

(RD-72-50) (AD 745 476)

Under a joint U.S./FAA and U.K./DTI work agreement, a STAN-37 localizer (85-foot aperture) was installed and subjected to various tests at National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. These included conformance to ICAO Annex 10 Category III ILS specifications, system performance, system and monitor stability and monitor operation under degraded system performance. It was concluded that the system characteristics met ICAO specifications, and that monitor executive action occurs as required when faults are present. System availability sufficient for Category III operation should be established during an evaluation under operational conditional conditions.

NA-72-16

RELATIONSHIP BETWEEN THE SAE SMOKE NUMBER AND JET AIRCRAFT SMOKE VISIBILITY

Gerald R. Slusher, December 1971 23p.

(RD-71-23)

A method was developed using the Society of Automotive Engineers (SAE) smoke numbers for calculating the exhaust smoke transmission for turbine engines, number of plume paths, and viewing angles. Criteria were developed relating the SAE smoke number to engine airflow and thus to engine size for conditions of visible and invisible smoke. Transmission of multiple plumes was calculated and presented.

NA-72-17

SIMULATION STUDY OF DIAMOND RUNWAY MARKS FOR AIRCRAFT APPROACH GUIDANCE

Thomas E. Zurinkas, June 1972 16p.

(RD-72-57) (AD 744 899)

A simulation study was made to determine a pilot's ability to establish a specific glide path angle by perceiving the apparent squareness of an oblong diamond mark on a runway. Twenty subjects were asked to say when they perceived squareness of the diamond marks. The subject's task was to adjust a movable simulated runway, which sloped upward or downward from level, changing the perspective of the marks until the first diamond mark in the runway centerline appeared to be square. The median viewing angle of each subject's judgments was his score. Two diamond centerlines of different dimensions were simulated: one with diamonds 10 feet wide by 75 feet long, and another with diamonds 10 feet wide by 150 feet long. The obtained mean of all of the scores for the 10/75 diamonds was  $5.59^\circ$ ; the obtained mean for 10/150 diamonds was  $2.70^\circ$ . This was about 25 percent below geometrically calculated unity, which was about  $7.50^\circ$  and  $3.75^\circ$ , respectively. The range of the scores was approximately  $3^\circ$  for the 10/75 diamonds, and approximately  $6^\circ$  for the 10/150 diamonds. In general, the results of this study do not support the hypothesis that the perception of squareness of a diamond runway marking is a sufficiently accurate technique for establishing a suitable glide path angle.

NA-72-18

INVESTIGATE INCOMPATIBILITY BETWEEN GROUND AND AIRBORNE MEASUREMENTS OF VOR  
SPACE MODULATION

Matthew Naimo, Jr.

Final Report, February 1972 63p.  
(RD-71-119) (AD 737 039)

The report describes an investigation into the cause of incompatibility between ground and airborne measurements of VOR space modulation when using the latest flight inspection receiver, FA-4165.3A. The effort included a survey of the existing procedures and equipment used through out the FAA, an evaluation of the ground measurement technique, and an evaluation of the airborne measurement technique. The result of the investigation identified problems areas with both the ground and airborne techniques, but the largest contributing factor to incompatibility is due to the erroneous indication, at times, of the 30-Hz variable monitor output of the FA-4165.3A flight inspection receiver.

NA-72-19

A STUDY OF ATMOSPHERIC IONIZATION: MEASUREMENT OF THE ION CONDITIONS IN AN  
ATC LABORATORY AND A REVIEW OF THE LITERATURE OF ION EFFECTS ON PERFORMANCE

Bruce L. Rosenberg

Final Report, May 1972  
(AD 742 474)

Reports of irritating sensations affecting the face, nose, and eyes when working at ATC radar positions motivated this study. The possibility was considered that an atmospheric ion imbalance, due to the high voltages present on the equipment could be the cause of the observed sensations. Accordingly, a project was initiated for the measurement of atmospheric ion levels. Ion densities for four mobility ranges were measured in several locations outside and inside a laboratory containing operating radar display equipment during the summer of 1970. Although the inside Total Ion Density was low, a significant Percent Excess Charge for very small ions was found in the vicinity of the RBDE-5 radar displays. The imbalance, in favor of positive ions, exceeded +33 percent. This positive imbalance, possibly the cause of the irritating sensations, might be due to the 20 kilovolt positive accelerating potential used for the displays. The literature on atmospheric ions was reviewed to determine the relationship between ion levels and task performance and health. The thresholds for the onset of deleterious effects of positive ions were tentatively defined. The importance of atmospheric ionization as an environmental factor relevant to the mission of the Federal Aviation Administration was documented.

NA-72-20

EVALUATION OF AIRCRAFT GROUND FIREFIGHTING AGENTS AND TECHNIQUES

George B. Geyer

Final Report, February 1972 252p.  
(RD-71-57) (AGFSRS) (AD 741 881)

An analysis of aircraft crash firefighting systems was made through a survey of known and newly developed agents, both blanketing and auxiliary, and of dispensing equipment. Laboratory studies were conducted to ascertain the most acceptable

agents and equipment for use in performing full-scale firefighting tests. Experiments were performed principally upon those agents which were manufactured in conformance with a Federal or Military specification or were listed and approved by a recognized testing laboratory. Full advantage was taken to avoid duplication of effort by accepting all published data which was conducted only with those agents considered worthy of additional testing. Full-scale tactical firefighting experiments were performed with medium size aircraft (B-47 Stratojet Bombers) to determine the effectiveness of each firefighting agent and the validity of the techniques and agent application rates employed.

NA-72-21

WING LEADING EDGE FUEL TANK IMPACT TESTS

Larry W. Hackler

Final Report, October 1972 55p.

(RD-72-83) (AD 751 522)

A typical jet transport wing with integral leading edge fuel tanks was subjected to impacts similar to those which could occur in the vicinity of an airport in an aborted takeoff or an abnormal landing. The problems with the test setup are discussed, also suggestions for improvement are included. The same wing was impacted with several birds to simulate bird strikes.

NA-72-23

OPERATIONAL SCALE ERROR OF 17 THREE-POINTER BAROMETRIC ALTIMETERS

Jack J. Shrager

Final Report, March 1972 19p.

The operational scale errors of 17 currently certified standard three-pointer aircraft altimeters were determined by three independent techniques. The results indicated that 12 of the 17 altimeters did not meet the scale accuracies required by FAR 43, Appendix E.

NA-72-24

INVESTIGATE AND ANALYZE DME TRAFFIC LOAD

George J. Hartranft and Harold Postel

Final Report, February 1972 31p.

(RD-71-109) (AD 737 038)

The report covers the development of a method of measuring DME traffic for both a DME-saturated and nonsaturated TACAN site. DME traffic counts were conducted at the following Eastern Region VORTACs: LaGuardia, Robbinsville, Coyle, Kenton, Deer Park, Sea Isle, and Yardley. The LaGuardia VORTAC experienced the highest peak traffic of the VORTACs tested. The LaGuardia traffic count indicates the system is operating at 66 percent of full-load capacity during peak traffic.

NA-72-25

TEST AND EVALUATION OF ENGINEERING MODELS OF TERMINAL AREA DME

George J. Hartranft

Final Report, March 1972 82p.

(RD-71-108) (AD 737 341)

The report covers the testing of two low-powered Distance Measuring Equipment (DME). The equipments were delivered to National Aviation Facilities Experimental Center (NAFEC) to evaluate suitability of design concepts for use in preparing a prototype specification. The laboratory tests dealt with the effects of continuous wave (CW) interference on reply delay, receiver sensitivity, and squitter rate: the effect of various squitter rates on airborne interrogators, the effect of various interrogation levels on receiver delay, and the effects of various transmitted pulse parameters on the pulse pair spectrum. The flight tests identified the coverage area provided by a 90-watt DME ground station to various commercial and general aviation type DME interrogators.

NA-72-26

TEST AND EVALUATION OF A PORTABLE SCANNING BEAM GUIDANCE SYSTEM

Vincent L. Bencivenga

Final Report, March 1972 102p.

(RD-72-16) (AD 739 256)

A portable scanning beam guidance system was installed and tested at 28 field locations by National Aviation Facilities Experimental Center (NAFEC) personnel. The sites selected were located at 16 different airports in the Eastern United States and were known to be difficult Instrument Landing System (ILS) sites. The system was tested both as a glide slope and as localizer. During these tests, the guidance equipment was not affected by terrain irregularities, taxiing aircraft, vehicle movement, buildings adjacent to the airfield, etc. The system was installed, calibrated, and initially aligned without the need for extensive flight testing to verify system performance.

NA-72-27

EVALUATION OF STOL INSTRUMENT LANDING SYSTEM (TALAR IV)

Glen D. Adams

Final Report, April 1972 32p.

(RD-72-15) (AD 740 063)

The FAA purchased two TALAR IV systems for use on short takeoff and landing (STOL) tests. TALAR IV operates at 15.5 GHz (Ku-band magnetron output), providing localizer and glide slope signals for approach guidance for aircraft equipped with a receiver. The FAA units were modified to provide glide slope angles between 6° and 9°, to include a transmitter monitor, and to transmit an identification code. The magnetron life is about 500 hours. The monitor is inadequate because of drift, but overall, the TALAR has been a reliable and useful tool. The guidance signals are generally of good quality. The transmitter location, in relation to the runway, affects the pilot's ability to set the aircraft down at the desired touchdown point.



NA-72-28

EXPERIMENTATION SUPPORT FOR DEMONSTRATION OF AN AUTOMATIC POSITION REPORTING  
TECHNIQUE AT OAKLAND, CALIFORNIA

Gerald E. Titherington, Michael J. Massimino, and James S. Beaty

Final Report, April 1972 81p.

(RD-71-92) (AD 741 147)

Progress in oceanic air traffic control has lagged behind domestic development because of incomplete radar and radio coverage and a lack of precise navigation capabilities. The advent of inertial navigation systems (INS), with a suitable air-ground data link, offers the potential for improvement of this situation. This report is the result of a joint government-industry effort in which automatic position reports from INS-equipped aircraft were picked up by VHF troposcatter antennas belonging to Aeronautical Radio Inc., the airlines' communications company. The signals were then transmitted via common carrier facilities to the Oakland Air Route Traffic Control Center of the Federal Aviation Administration (FAA), where they were used as an input to a computerdriven graphic display similar in appearance to a radar console. This subsystem also had the capability of extrapolating flights in the absence of data from the aircraft. Air traffic controllers from the FAA's National Aviation Facilities Experimental Center (NAFEC) trained and supervised a group of the Oakland controllers in the use of the display device. These controllers used this experience as a basis for subjective evaluation of the concept, and to make suggestions for improvements.

NA-72-29

AIRCRAFT EXTERIOR LIGHTING AND MARKING

George E. Rowland, Carl A. Silver

Final Report, May 1972 66p.

(RD-72-24) (AD 741 531)

This study investigates the contemporary state of human factors knowledge concerning aircraft exterior lighting and marking. Efforts to increase conspicuity or impart information through resort to exterior marking or painting are now and, in the absence of an unforeseen technological breakthrough, will probably continue to be essentially useless. A simple white-on-top, black-on-bottom paint scheme, which leaves about one-fourth of a metal aircraft bright aluminum to cause specular reflection of sunshine, is recommended as the most likely overall compromise paint design.

An attempt to define a standardized exterior lighting system failed because sufficient hard data does not exist to compare system components. Large scale field research to compare all components of all major systems is urgently required. This research would compare red versus white beacons, beacons plus running lights versus either alone and all other major combination. Research is outlined for study of backscatter and daylight lighting. In addition, eight experiments are described which would investigate innovative new ideas in coding concepts which may have applicability. Collectively, the research program outlines a very advanced, very large-scale exterior lighting research program for the FAA to conduct at NAFEC. It is concluded that a contemporary standard lighting system is feasible at present and should be adopted on the basis of a massive field trial. At the same time, an imaginative exploratory research program is urgently needed.

NA-72-30

EVALUATION OF TEST DATA ON JET ENGINE COMBUSTOR BURN-THROUGH FLAMES

H. S. Pergament, R. R. Mikatarian

Final Report, March 1972 55p.

(RD-71-100) (AD 752 603)

A method is developed to interpret flat plate impingement pressure and temperature data taken in jet engine combustor burn-through flames in terms of free stream velocities, pressures, temperatures, etc. These flames, which are high-temperature, turbulent underexpanded sonic jets, are caused, in practice, by the combustion gases impinging on (and burning a hole through) the wall of the combustor. The free stream property data are needed to compute local heat transfer coefficients, which must be known to determine whether potential firewall materials can withstand a burn-through flame. Turbulent convective heat transfer coefficients are computed herein, primarily to determine radiation and conduction corrections to the temperature measurements. The influence of mixing between the burn-through flame and ambient air on flame properties is also studied, and a correlation is developed which relates the angle of spread of the mixing region to the enthalpy flux at the burn-through hole. Suggestions regarding future experimental and theoretical programs are made.

NA-72-32

INERTIAL LOCATOR TEST AND EVALUATION

John E. Wall

Final Report, February 1972 81p.

(RD-72-3) (AD 736 515)

A feasibility model of an Inertial Locator Equipment (ILE), developed by the Massachusetts Institute of Technology (MIT) Charles Stark Draper Laboratory, was designed to provide aircraft position information and on-board computer data processing for flight inspection of VOR, TACAN, VORTAC, and ILS facilities. Following equipment installation and preliminary flight tests at the contractor's flight facility located on Hanscom Field, contractor/NAFEC development tests were conducted at Atlantic City, New Jersey, using NAFEC's theodolite and radar tracking and computer facilities. The development test effort concentrated on system performance in accomplishing ILS flight inspection. This report evaluates ILE performance based on data collected during development testing. It was concluded that the feasibility model of the ILE, even with the computer updating technique used, did not meet performance accuracy design goals established for the feasibility model by Engineering Requirement FAA-ER-340-002. However, the ILE demonstrated a definite potential for performing the ILS inspection mission with inertial equipment. The usefulness and flexibility of an on-board general purpose computer were amply demonstrated. Improvements in updating techniques, alignment procedures, and hardware are required prior to further evaluation.

NA-72-33

EVALUATION OF A TWO-BAY ANTENNA FOR VOR APPROACH MARKER BEACON

Wesley O. Mickey

Interim Report, March 1972 45p.

(RD-72-11) (AD 738 671)

The Scanwell two-bay marker beacon antenna was installed and tested at three sites at the National Aviation Facilities Experimental Center (NAFEC). Tests were performed with two aircraft, a NAFEC T-29 aircraft and a flight inspection DC-3 aircraft. The DC-3 was equipped and calibrated as determined by the investigation of the marker beacon flight inspection system, ( Report No. FAA-RD-71-80). Preliminary test at two sites, the asphalt Multiple Object Phase Tracking and Ranging (MOPTAR) site and 500 feet northwest of the MOPTAR site were performed with the T-29 aircraft. These tests determined that the Scanwell antenna radiation pattern provided the desired ratio 8:3 or higher, and that further testing was necessary to determine the power required to obtain the size pattern desired. Tests were performed with the DC-3 aircraft with the antenna installed at the approach end of runway 4. The output power tested of 1, 2, and 4 watts, was limited by the capabilities of the TV-26 transmitter. Power required to be assured of an 8,000-foot minimum major axis at 400 feet above ground level (AGL) was 32 watts and was determined by projecting the increase of the radiation pattern observed when the power to the antenna was doubled.

NA-72-34

EVALUATION OF POLYURETHANE SHROUD DESIGNED TO PREVENT TACAN WEATHER OUTAGES

George J. Hartranft

Final Report, August 1972 39p.

(RD-72-78) (AD 747 459)

The report covers field evaluation at the Fairfield, Utah Vortac of a polyurethane shroud installed over the TACAN antenna. The evaluation determined the effectiveness of the shroud in preventing and removing snow and ice accumulations from the TACAN antenna. The data indicated that although the shroud did not completely eliminate weather outages; it was successful in preventing and removing snow and ice accumulations.

NA-72-36

INTENSITY CONTROL OF FLASHERS

Bernard Weinstein

Final Report, June 1972 58p.

(RD-72-54) (AD 745 467)

This report describes tests and experimentation with intensity control of condenser discharge lights (flashers) with a three-step intensity control, and used in a Runway Alignment Indicator Light (RAIL) System as part of a Medium Intensity Approach Light System with sequenced flashers (MALSR) during both day and night and over a wide range of visibility conditions. Also, test and experimentation were conducted with a voltage sensing circuit intended to operate the intensity controlled MALSR from the Control Tower using current changes in the runway lighting circuit. Two intensity controlled MALSR systems one, 2,400 feet long on Runway 4, and another 3,000 feet long on Runway 13 were flight tested

during the evaluation. The results of the evaluation tests indicated the following: (1) the voltage sensing circuit using current changes in the runway lighting circuit provided satisfactory operation of the MALSR from the Control Tower, (2) the intensity controlled MALSR operated satisfactorily and adequately supported flight operations during both day and night and over a wide range of visibility conditions, (3) compatible intensity levels between the MALSR and the runway lights were obtained to provide a satisfactory intensity balance for flight operations during the weather conditions flown, and (4) the operation of condenser discharge lights during night VFR and IFR conditions were not distracting and did not subject pilots to annoying glare.

NA-72-37

HUMAN ENGINEERING ANALYSIS OF AIRPORT LIGHTING CONTROL PANELS AND A PROPOSAL FOR A NEW DESIGN

James E. Grambart

Interim Report, November 1972 38p.

(RD-72-93) (AD 752 134)

The purpose of this project was to design an improved airport lighting control panel for use in airport traffic control towers. Data on the physical characteristics of in-use panels and operational experience of users were collected at nine control towers in the Eastern Region. The need for a cleanly designed, compact, and easily read and activated lighting system display/control panel was documented. In response to this requirement, a new design was proposed. An important feature of this design is that the operation of the auxiliary systems is contingent upon the activation of the main runway lights in such a manner as to minimize the number of control units. Rather than have one control unit for each combination of runway and auxiliary lighting systems (the number being equal to the product), there is one control unit for each main runway lighting system and one control unit for each class of auxiliary lighting systems (the number being equal to the sum). As the number of runways and lighting systems increases, the adoption of the proposed design should result in a striking reduction in control panel complexity and an increase in efficiency and economy. Because of the variety of regulator switches employed in the several different approach lighting and runway lighting systems presently in use, electrical engineering effort would be required to adapt this human engineering design of the tower cab control panel to actual field installations.

NA-72-38

PERFORMANCE OF A DC-9 AIRCRAFT LIQUID NITROGEN FUEL TANK INERTING SYSTEM

E. P. Klueg, W. C. McAdoo, W. E. Neese

Final Report, August 1972 74p.

(RD-72-53) (AD 748 116)

Nitrogen inerting protection for the fuel systems in commercial aircraft has been proposed to reduce fire and explosion hazards associated with refueling, electrical and mechanical failures, engine failures, in-flight fires, lightning strikes, and survivable crashes. A liquid nitrogen fuel tank inerting system was developed and installed on an FAA DC-9-15 aircraft. Instrumentation equipment and measurement techniques for evaluation the installed fuel tank inerting system performance were developed. A flight test program was conducted to demonstrate compliance of the

DC-9 inerting system with applicable airworthiness standards, to evaluate oxygen concentration measurement techniques, and to verify that the installed inerting system maintained an explosion safe mixture in the fuel tanks over the entire flight envelope. Oxygen concentrations at various locations of the ullage and vent systems and the operating characteristics of the inerting system were determined during the flight test program. The inerting system was determined to be capable of maintaining a mixture in the fuel system vents and tank vapor spaces having a volumetric oxygen concentration less than 8 percent under all normal and emergency flight conditions. The in-flight oxygen analyzer equipment and the measurement techniques utilized provided the oxygen concentration information required to evaluate the performance of the inerting system. Oxygen concentration measurements in each enclosed vapor space, under critical fueling and flight conditions, and in each vent system throughout each test flight were required.

NA-72-39

INDEX OF NAFEC TECHNICAL REPORTS, 1967 — 1971

Compiled by NAFEC Library

Final Report, May 1972 106p.

(AD 742 849)

This report is an index of all technical reports which were assigned NA numbers and published by NAFEC during the period 1967 through 1971. Entries are arranged by NA number and include titles, authors and full abstracts. Separate sections contain indexes by subject, author, RD number, DS number, project number, and contract number.

NA-72-41

COLLISION AVOIDANCE: AN ANNOTATED BIBLIOGRAPHY, SEPTEMBER 1968 — APRIL 1972

Dorothy Bulford

Final Report, August 1972 262p.

(AD 746 863)

In November 1968 a bibliography consisting of 1013 references without annotations was issued as FAA report number NA-68-54 (AD 677 942). This present work supplements that report. In addition to the Subject and Corporate Author Indexes of the 1968 listing, this bibliography includes a Personal Names Index which will help find secondary authors or locate names mentioned in titles and abstracts.

NA-72-43

A MAGNETIC TAPE STUDY

Richard Piech

Final Report, August 1972 10p.

(RD-72-66) (AD 788 115)

A study was conducted to identify problem areas in the use and handling of Magnetic Tapes. The study included determining the causes of tape errors and whether it is advantageous to the FAA to recondition tapes on a periodic basis. An engineering investigation also was conducted to select the optimum equipment for a magnetic tape maintenance program.

NA-72-46

TASK 11, IMPROVED DVOR LOW LEVEL RECEIVER MAINTENANCE SIMULATION

Barry S. Brayer

Final Report, January 1973 49p.

This report discusses system performance with Single Sideband Doppler VOR (SSDVOR) and Double Sideband Doppler VOR (DSDVOR) as indicated by low level or receiver maintenance through simulation of detuned intermediate frequency amplifier stages. The simulation was accomplished by shifting the carrier frequency of the Doppler VOR Transmitter. Indicated bearing error on 10 VOR receivers was recorded during tests at the National Aviation Facilities Experimental Center. Based on the simulation test results it was concluded that the DSDVOR system provides less course error than the SSDVOR system, and that careful alignment of the receiver on the particular DVOR channel frequency minimizes course error.

NA-72-47

AN EVALUATION OF POTENTIAL REFLECTION PROBLEMS WHEN USING THE NAS MODEL 3d DISPLAY IN THE VERTICAL POSITION IN AIR ROUTE TRAFFIC CONTROL CENTERS

Lee E. Paul

Interim Report, September 1972 25p.

(RD-72-60) (AD 748 151)

A production version of the NAS Model 3d plan view display was taken to the Atlanta, Oakland, and Cleveland Air Route Traffic Control Centers and operated in a sector radar position at each. A typical digital sector display was simulated through the use of a Raytheon 704 computer and tape drive. A total of 166 controllers observed the display and filled out questionnaires on it, 118 seeing the display with the safety shield in place, 48 seeing it with shield removed. Ambient light level measurements were made at each of the centers. A small percentage of the controllers stated that reflections were a serious problem when the safety shield was in place. With the shield removed, a significantly smaller number indicated a reflection problem. There were very large differences in the ambient light levels at the centers.

NA-72-48

FIREFIGHTING EFFECTIVENESS OF AQUEOUS-FILM-FORMING-FOAM (AFFF) AGENTS

George B. Geyer

Final Report, April 1973 63p.

(AD 774 025)

Information was obtained by conducting laboratory experiments and full-scale fire-modeling tests which were of value in estimating the firefighting effectiveness of two aqueous-film-foam (AFFF) agents. Minimum quantities and application rates were established for each AFFF agent in relation to the size and configuration of simulated aircraft ground fuel-spill fires involving JP04, JP-5 and aviation gasoline.

NA-72-49

EVALUATION OF INSULATION FOR CRASH FIRE PROTECTION OF NEW FLIGHT RECORDERS

Thomas Rust, Jr.

Final Report, September 1972 39p.

(RD-72-75) (AD 743 376)

The work performed under this project involved the evaluation of flight recorder insulation arrangement relative to their ability to provide thermal protection for record tapes under conditions of crash fire. The evaluation encompassed fire testing four different types of insulation arrangements in accordance with three different time-temperature fire environments.

It was found that a combination of high-temperature insulation and a heat sink material employing water as the heat absorber provided the best protection for the record tapes when exposed to a realistic severe thermal environment.

NA-72-57

DEVELOP ACCELERATION AND BRAKE MONITOR SYSTEM

Samuel V. Zinn, Jr.

Interim Report, November 1972 24p.

(RD-72-112) (AD 752 562)

A literature search was conducted to summarize the results of previous work performed in establishing criteria for continuing the development of an instrument system which will aid pilots in making critical decisions during takeoff and landing rolls. The search revealed that many national and international studies had been made during the past 15 years, but interest diminished after 1963.

It appears that much talent and work were applied for creating a monitor but no acceptable units were produced. Additional research and evaluation is considered necessary.

NA-72-60

SQUARE WAVE VOR TESTS

Louis A. Dvorsky

Final Report, February 1973 101p.

(RD72-121) (AD 757 053)

Airborne and laboratory tests were performed on the 5X Square Wave VOR. Modification of both the ground facility and airborne receiver was necessary for an improvement in flyability due to suppression of reflected VOR signals. Compatibility flight tests were made using both modified and unmodified receivers on four-loop and SVOR facilities. Laboratory tests were performed on 12 different unmodified receivers to determine their response to sine and square wave modulation inputs.

NA-72-61 DEVELOPMENT OF LOW-COST COCKPIT/OUTSIDE TIME SHARING TRAINING EQUIPMENT

Warren G. Crook

Final Report, November 1972 20p.

(RD-72-95) (AD 753 924)

Ten certificated pilots were given time-sharing training using a low-cost visual in-cockpit device. Training sessions in a ground trainer with subsequent flight checks in an airplane showed marked improvement in cockpit/outside visual scanning and piloting proficiency. Pilots expressed favorable comments regarding use of the concept for student pilot training. Three pilot training schools also evaluated an in-cockpit aural signal device designed to prompt pilots to scan outside for other aircraft. The device received unfavorable comments from student pilots and flight instructors due to excessive amounts of annoyance and distraction, and was not recommended as a training aid.

NA-72-62

TRANSCRIBED PILOT REPORT (PIREP) BROADCAST SYSTEM, TEST AND EVALUATION

James G. Dong

Final Report, October 1972 26p.

(RD-72-97) (AD 750 828)

This report presents results of an automatic transcribed pilot report (PIREP) system fabricated at the National Aviation Facilities Experimental Center (NAFEC). The system utilized an off-the-shelf endless loop tape recorder which was integrated in the Flight Service Station/Very High Frequency Omnidirectional configuration at selected sites. Live operational tests were accomplished to determine equipment deficiencies and operational suitability for consideration of expanding the PIREP concepts to other sites. From the operational tests, the concept was not adopted because of pilot apathy to transmitting PIREPS.

NA-72-63

EVALUATION OF HIGH-ACTIVITY LEVEL TOWER CAB

J. Roy Bradley, Jr.

Final Report, October 1972 56p.

(RD -72-111) (AD 751 933)

This project was conducted to develop operator's consoles lighting systems, and other features that would provide a modern, efficient, and pleasant operating environment for the Welton Becket and Associates Architects designed octagonal tower cab, which is proposed for use at high-activity level airports. A full-scale mockup of the tower cab was constructed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. The mockup was equipped with experimental consoles, lighting systems and appropriate environmental innovations. A 3-week evaluation was conducted with participation by air traffic control specialists from nine of the 11 Federal Aviation Administration's Regions. Results indicate that the console configurations satisfied operational requirements and were rated very good; the custom lighting systems were excellent; and the overall environment, created in the laboratory, was modern, efficient, businesslike and particularly acceptable. It was noted that individual facility requirements would dictate determination of the console height, along with the location of particular equipments.



NA-72-64

VISUAL APPROACH PATH INDICATOR (VAPI) EVALUATION

Robert F. Gates, Thomas H. Paprocki

Final Report, September 1972 15p.

(RD-72-49) (AD 748 718)

The Tri-color Visual Approach Path Indicator (VAPI II), as modified for improved identification, was evaluated for suitability as part of a two-segment visual approach slope indicator system, and for possible incorporation into the National Airspace System. The unit was tested, using the standard Simple Abbreviated Visual Approach Slope Indicator (SAVASI) system as a control for comparison, to determine effectiveness, environmental suitability and dependability of operation. The test results lead to the conclusion that, for a number of valid reasons, the VAPI unit was markedly inferior to the SAVASI system, and should not be considered either for use in the two-segment VASI, or for inclusion within the National Airspace System.

NA-72-65

TACAN-DME FALSE DISTANCE LOCK-ON

George Hartranft, Matthew Naimo, Harold Postel

Final Report, February 1973 64p.

(RD-72-98) (AD 757 238)

The report covers the results of laboratory and field tests of various TACAN ground station modifications designed to minimize the false DME problem. An airborne and ground data collection package was designed to record the percentage of false replies synchronous with an aircraft interrogation. The modifications tested included a modified GSN-9 TACAN receiver developed by ARINC, a tighter decoder tolerance modification (Tulsa modification) designed by Stanley Milner of the Tulsa VORTAC, a jettering dead time gate designed by LTV electro Systems, Montek Division, and a retriggerable long dead time gate (Crazy Woman) modification designed by George Olton of the Crazy Woman, Wyoming VORTAC. Although all modifications were successful in reducing the percentage of false DME, the Crazy Woman modification was the most successful in eliminating all false DME caused by multi-path air-to-ground interrogations.

NA-72-73

VASIS SIGNAL TRANSITION ZONE AND COLOR MODIFICATIONS

Robert F. Gates, Thomas H. Paprocki

Interim Report, September 1972 24p.

(RD-72-91) (AD 748 682)

This report covers the results of a portion of the overall project effort to develop an improved Visual Approach Slope Indicator System (VASIS). A method of decreasing the VASI signal pink transition zone was evaluated and the effect of substituting different color density and hue red filters was studied. As a result of the testing, it was concluded that the standard VASI signal can be significantly improved by a slight modification to the geometry of the transition bar and by substitution of different filters.

NA-72-77

SIMULATED GROUND-LEVEL STOL RUNWAY/AIRCRAFT EVALUATION

Roman M. Spangler, Jr.

Final Report, September 1973 175p.

(RD-73-110) (AD 776 899)

A De Havilland DHC-6, Series 100 Twin Otter was flown by a representative group of pilots on various steep-gradient approaches onto a ground-level STOL runway. Approximately 800 approaches and landings were accomplished to provide a data base to approve a first-generation STOL operation. Areas investigated included aircraft handling and response on steep-gradient approaches with various approach electronic beam sensitivities; location of the ground point of intercept; co-load versus split localizer/glide slope signal source; obstacle clearance requirement field length requirements; and influence of command steering on aircraft/pilot performance.

NA-72-80

THE 1972 SEMINAR ON OPERATIONAL PROBLEMS OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM

Seminar Report, April 1973 249p.

(AD 763 135)

This Air Traffic Control Radar Beacon System (ATCRBS) Seminar was the first of its kind dealing specifically with ATCRBS problems.

Personnel attended the seminar from management, research, maintenance and operational organizations of the Federal Aviation Administration. It was sponsored by National Aviation Facilities Experimental Center (NAFEC) and Systems Research and Development Service (SRDS). It was held February 8 through 11, 1972, at the Shelburne Hotel, Atlantic City, New Jersey. Papers presented by 26 attendees are reproduced along with partial transcripts from associated discussions. The subject material is arranged according to the following titles which correspond to the workshops of the seminar: Introduction, Broken Targets, False Emergency Alarms, Electromagnetic Interference, False Targets, Missing Targets and Fading.

NA-72-87

MEASUREMENT & ANALYSES OF ASR-4 SYSTEM ERROR PART II: ANALYSES

Allen C. Busch, Paul W. Bradbury

Interim Report, August 1973 152p.

(RD-73-62) (AD 766 609)

The positional accuracy of aircraft radar targets as displayed in an Air Traffic Control airport surveillance radar system (ASR-4) was sought as one of the inputs essential for determining aircraft separation standards. Using inputs from the Atlantic City (N.J.) ASR-4, the radar targets of two test aircraft were photographed as displayed in both primary and beacon modes on scan-converted and PPI displays. The displayed positions were related to simultaneous precision track from single-target instrumentation radars (EAIR and TAIR) to derive error measures from range, azimuth, and separation. The analysis program employed a least squares analysis of variance on some 17 response variables for a set of six system control variables. The data clearly demonstrated the strong interdependency of the individual components that contribute to radar system separation error by the presence

of positive correlaton coefficients and frequent statistically significant F ratios for the main effects of the six control variables. Furthermore, it was noted that the tails of the distribution of the radar separation error response measure were not normally distributed.

NA-72-89

FLIGHT TEST AND EVALUATION OF HELIPORT LIGHTING FOR IFR

Thomas H. Paprocki

Final Report, December 1972 26p.

(RD-72-133) (AD 753 058)

Various aproach lighting system patterns, developed through mockup and VFR flight testing efforts, were evaluated to determine their effectiveness in providing visual guidance for helicopter IFR approach and landing operations. Four basic lighting configurations were flown, under actual IFR weather conditions, by experienced helicopter subjects pilots. As a result of information collected through in-flight recording of objective data and post flight completion of pilot questionnaires, one of the lighting patterns was chosen as most effective for the conditions specified.

NA-72-91

SAFE BOMB LOCATION

Jack Avery, Bob Bistrow, Chris Gunther, Jag Hajari, Al Opsahl

Final Report, November 1972 61p.

(RD-72-94) (AD 906 173L (USGO))

This report covers an analytical study to determine the optimum location on a 727-100 airplane for positioning a discovered explosive device. The study consisted of (1) A review of existing methods for predicting blast effects on typical aircraft structure, (2) Selecting candidate locations for analysis, (3) Determining minimum and maximum hole sizes resulting from detonation of a given amount of explosive at the candidate locations, (4) Determining the aircraft's capability for continued safe flight with minimum and maximum holes at the candidate locations and (5) Developing procedures which would provide the best chance of a safe landing in the event of detonation. The study concludes that a location adjacent to the mid-galley door would be the optimum locatin, that the aircraft would survive with the minimum hole size at any of the three locations and that the maximum hole size would be catastrophic at all but the mid galley door location where, under conditions of limited air speed and gust velocity, continued flight and landing could be effected.

## INTRODUCTION

The practice of assigning NA numbers to technical reports published by the National Aviation Facilities Experimental Center was begun during the autumn of 1967. An index published earlier (NA-72-39; AD 742 849) listed reports published during the period 1967 - 1971. This index includes all such reports which were issued from 1972 through 1977. Because assigned numbers are sometimes changed or discarded during the reports preparation process, missing numbers are not indicative of missing reports. All published reports are listed.

The arrangement in this listing is by the NA number. Each entry includes the title, author, date, number of pages, and a full abstract. Where appropriate, other bibliographic information is also included such as Systems Research and Development Service (RD) numbers, and AD numbers. The AD number indicates that the report is available from the National Technical Information Service, indefinitely. Prices are set by NTIS and are subject to change.

There are a few reports listed without AD numbers. Application for copies of these should be made to the Director of the FAA Service which sponsored the report.

FAA personnel will find copies of NAFEC reports in the libraries in Regions, Centers, and The Department Library in Washington.

The indexes at the end of this report provide access to the abstracts by subject, author, and RD numbers. The subject headings, with some exceptions, were taken from the NASA Thesaurus, 1976 edition.

INDEX OF NAFEC TECHNICAL REPORTS  
1972-1977

NA-72-2

INTERMEDIATE ACTIVITY LEVEL TOWER CAB EVALUATION - PHASE II

J. Roy Bradley, Jr.

Final Report, December 1971 51p.

(RD-71-104) (AD 735 131)

This project was conducted to determine Air Traffic Controllers acceptance of an intermediate activity level airport traffic control tower, proposed for construction on a national basis, and to obtain suggestions for improving the proposed facility. Full-scale mockups of the tower cab and associated junction room were constructed and equipped with operational equipments at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey. A 2-week evaluation was conducted with participation by air traffic control specialists from each of the 11 Federal Aviation Administration's regions. Results indicate that the proposed tower would be highly acceptable from an operational, as well as an environmental standpoint. Concern was expressed over the large size of the tower cab corner posts and window muillions and over unknown factors relative to the adequate performance of the heating, ventilating, and air conditioning system. Numerous suggestions for both local and national application were determined and documented.

NA-72-6

ALTIMETRY DISPLAY STUDY: PART THREE - REVIEW OF R&D ON DISPLAY READABILITY

Jack J. Shrager

Final Report, May 1972, 81p.

(RD-46,III) (AD 743 094)

A review of all literature published since 1960 relating to aircraft height or altitude display was made. This review was supplemented by a series of conferences with experimentalists currently working in this field. The results of the literature review and series of conferences are evaluated and summarized, and this is further supplemented by an annotated bibliography of the documents included in the literature review. This report is Part Three of a four-part altimetry study, including: Part One - The overall altimetry study conclusions and recommendations as drawn from results of the other three study parts taken together; Part Two - An accident analysis by Flight Safety Foundation to determine whether altimetry is a frequent causal factor; and Part Four - A survey of the current display population and an estimation of improvement costs by MITRE, to determine the impact of a mandated change.

NA-72-92

THE FEASIBILITY OF BURNER-CAN BURN-THROUGH THERMAL DETECTION PRIOR TO ENGINE CASE RUPTURE

Richard Hill

Final Report, January 1973 35p.

(RD-72-134) (AD 756 765)

Full-scale tests simulating engine combustion section thermal failures (burn-through) were conducted using a J57 engine (cowled and uncowed) to determine the feasibility of detecting a burn-through prior to its occurrence by monitoring engine skin temperature. Results of the tests indicated that as few as four thermocouples, located 90 degrees apart around the diffuser case and/or burner can case, could detect a burn-through prior to engine case rupture.

NA-72-95

ATC CONCEPTS FOR V/STOL VEHICLES, PARTS 1 AND 2

Sidney B. Rossiter, John Maurer, and Paul J. O'Brien

Final Report, April 1973 63p

(RD-73-47) (AD 759 864)

Two dynamic simulations were conducted, using saturated Short Takeoff and Landing (STOL) aircraft traffic sample inputs, to study the effects of various aspects of STOL aircraft operations within the Air Traffic Control System. One investigated the effects of STOL aircraft operating at a downtown STOLport within the New York terminal area complex; the other investigated the effect of STOL aircraft operating on various configurations of STOL runways at a high-density, multi-runway, conventional takeoff and landing (CTOL) airport. It was concluded that STOL operations can be accommodated at a downtown STOLport; however, where airspace is limited, intricate profiles requiring a high degree of aircraft performance may be required. The performance of these profiles should be an onboard responsibility using highly accurate area navigation equipments with the ATC facility serving as monitor. The current method of controller speed commands can be used as an interim method of metering and spacing pending more sophisticated methods, but requires flexible aircraft speed parameters and close cooperation between pilot and controller. As an aid to airspace utilization, a glide slope of  $7\frac{1}{2}^{\circ}$  is beneficial and may be essential. It was further concluded that the least effect on CTOL operations at a CTOL/STOL airport is achieved by a parallel system of STOL runways bordering upon the CTOL complex. The techniques for controlling STOL aircraft at a CTOL airport are similar to those applied to CTOL aircraft; however, more emphasis is placed on speed control as opposed to radar vectoring because of the criticalness of the operation within the confines of limited airspace. A steep glide slope, preplanned pilot-performed flight tracks, and the limiting of the number of STOL routes into the terminal area are aids to an efficient STOL operation.

NA-72-96

JET ENGINE BURN-THROUGH INVESTIGATION VOL. I SONIC ANALYSIS

R. W. Schumacker

Final Report, March 1973 80p

(RD-72-149, I) (AD 758 349)

The work performed during this program was directed toward determining the acoustic characteristics of simulated burn-through failures. To determine the feasibility of detecting this failure acoustically two types of jet engines (J-47 and J-57) were modified to simulate burn-through failures. Magnetic tape recordings of the modified engines were made to determine the extent of the acoustic spectrum, the relationships of engine speed to failure related sound pressure levels and acoustic spectrum, the effect of sensor location to detect the failure acoustically and characteristic acoustic spectra at burn-through. The recorded data was analyzed by real time spectrum analysis and mean square techniques. Results indicated that the simulated burn-through failure acoustic spectra consists primarily of broadband random noise above 5 kHz. It was also determined that sensor location is an important factor in detecting burn-through failures. Based on the results it is concluded that acoustic detection of a burn-through failure is feasible. Recommendations for a monitor and detector based on the results of this program have been included. Volume II contained engine tests raw data and is available on loan from the DOT Library Services Division, TAB-494, 800 Independence Avenue, Washington, D.C. 20591.

NA-72-102

STUDY OF CAPABILITIES, NECESSARY CHARACTERISTICS AND EFFECTIVENESS OF PILOT GROUND TRAINERS

Peter Stanek, Ph.D.

Final Report, January 1973 35p.

(RD-72-127) (AD 755 681) (Vol. I)

(AD 755 682) (Vol. II)

An experiment was conducted to test the capabilities, necessary characteristics, and effectiveness of Pilot Ground Trainers in developing primary aeronautical skills, those maneuvers and procedures defined in Federal Air Regulations 61.37, 61.87, 61.117 and appropriate Flight Test Guides, limited to aircraft, single-engine, land. During the first phase of the experiment, 30 subjects were trained to proficiency under part 61.87, fifteen in aircraft only and fifteen in combined ground trainer and aircraft. During the next phase, 20 of the original 30 were trained to proficiency under 61.37 and 61.117, 10 in each group. A third phase of the experiment tested additional subjects in various procedures with varying levels of simulator capability. The results of the experiment show which maneuvers and procedures may be taught effectively and efficiently in a ground trainer. This Addendum reviews flight instructors' ideas on the applicability of ground trainers in a primary curriculum, based upon their experience in this project. Volume I contains the main test. Volume II contains the Addendum, Summary of Flight Instructors'.

NA-73-1  
EVALUATE IMPROVED AIRPORT BEACON  
R. Johnston  
Final Report, March 1973 25p.  
(RD-73-25) (AD 757 934)

Two forms of experimental beacons, strobe and incandescent, were tested to determine their suitability as improved replacement of the standard 36-inch rotating airport beacon presently in use. Neither unit demonstrated a clearcut superiority over the standard beacon, and the need for further development effort was indicated. A type of low-cost incandescent airport beacon was evaluated at the same time and found suitable for use at smaller, secondary airports.

NA-73-3  
DESIGN CALCULATIONS FOR A HALON 1301 DISTRIBUTION TUBE FOR AN AIRCRAFT CABIN FIRE EXTINGUISHING SYSTEM  
Jack A. Jones, Constantine P. Sarkos  
Final Report, April 1973 35p.  
(RD-73-32) (Ad 758 350)

Theoretical calculations were performed to aid in the design of a perforated tube that will uniformly distribute Halon 1301 throughout the unventilated passenger cabin of a commercial air transport.

Conditions for the calculations were those of a passenger cabin of a DC-7 fuselage, with a volume of 4000 cubic feet and a length of 72 feet, being used as a test article for evaluating the performance of such a system. Four separate calculations were made to determine the (1) size and number of orifices in the tube required for various Halon 1301 discharge rates; (2) pressure drop as a function of tube diameter and discharge rates; (3) time required to fill the tube with Halon 1301 for various tube diameters; and (4) cabin temperature and pressure after completion of Halon 1301 discharge. The first calculations indicated that for a given discharge time, the required orifice diameter decreased slightly with increasing orifice number for a large number of orifices (about 40 - 50). The pressure drop was shown to be a strong function of both tube diameter and discharge time; however, practical tube diameters could be selected to assure a negligible pressure loss - a system feature which allows orifices equally spaced with the same diameter. It was demonstrated that the fill time would be less than 10 percent of most normally used discharge times - author desired system feature. Thermodynamic calculations predicted a 38° F Cabin temperature after complete discharge of agent with an initial cabin temperature of 70° F and relative humidity of 50 percent.

NA-73-4  
AUTOMATED SELECTION OF VOR, ILS, AND TACAN/DME FREQUENCIES  
T. Steger, R. Johnson  
Final Report, May 1973 75p.

This report describes in detail a computer program developed to automate the selection of VOR, ILS, and TACAN/DME frequencies. It includes a thumbnail sketch of the need for such a capability and describes in layman's language: the program logic involved for this problem; the advantages of automatic frequencies selection



in general; and some possible future applications. The results of an operational evaluation are highlighted and among other conclusions it was concluded the complete program offers a savings in time with no sacrifice in accuracy.

NA-73-13

THE USE OF GROUND COVER MATERIALS TO SUPPRESS FUEL SPILL FIRES

George B. Geyer, Lawrence M. Neri, Charles H. Urban

Final Report, July 1973 20p.

(RD-73-74) (AD 763 447)

Small-scale experiments were conducted to determine the effectiveness of crushed and graded stone aggregate in preventing or retarding the rate of flames propagation from a fixed-ignition source when it was employed as a simulated ground cover material under controlled experimental conditions, for each of three aviation fuels. Tests included the use of loosely packed aggregate and no-fines concrete made with the same material. No significant difference in the rate of flame spread was noted between the loosely packed aggregate and no-fines concrete under equivalent test conditions. The experiments showed that the effectiveness of an aggregate in retarding flame propagation was a function of its size and the flash point of the hydrocarbon fuel and of its depth below the surface of the simulated ground cover. The fire suppression and/or containment effectiveness of the ground cover materials increased as the size of the aggregate decreased and the flash point of the fuel increased and as the depth of the fuel below the surface of the stone increased.

NA-73-14

TESTS OF THE VEGA AIRCRAFT RADAR ENHANCING SYSTEM (VARES)

Dominick L. Offi

Final Report, April 1973 43p.

(RD-73-88) (AD 759 146)

A cross-band radar/beacon system, designed to operate within the constraints of the Airport Surveillance Radar/Air Traffic Control Beacon Interrogator (ASR/ATCBI) environment was evaluated at the National Aviation Facilities Experimental center (NAFEC). The equipment, known as the Vega Aircraft Radar Enhancing System (VARES) was tested to determine technical as well as operational characteristics.

The VARES equipment, as originally designed, was not electrically nor mechanically compatible with the ASR/ATCBI system, nor with the aircraft available at NAFEC. With proper modification, the system provided an increased radar detection capability. In addition, limited tests indicated evidence of possible interference with the ATC Beacon System.

NA-73-15

CAPABILITIES, NECESSARY CHARACTERISTICS AND EFFECTIVENESS OF PILOT GROUND TRAINERS  
PHASE II, VISUAL REFERENCE FLIGHT MANEUVERS

Robert J. Ontiveros

Final Report, August 1973 52p.

(RD-73-108) (AD 765 961)

An experiment was conducted at the National Aviation Facilities Experimental Center (NAFEC) to determine the capabilities, necessary characteristics and effectiveness of pilot ground trainers required for developing primary aeronautical skills. Ten nonpilot subjects were trained to proficiency in presolo Visual Flight Rules (VFR) flight maneuvers using a fixed-base pilot ground trainer. A simplified visual display interconnected to the ground trainer, which provided the VFR environment, responded to flight control and power inputs simulating motion in the pitch, roll, and yaw axes. Subject flight performance capability achieved through ground trainer instruction was evaluated by a flight check in a single-engine aircraft. Project results indicate that a positive and effective transfer of training for performing a majority of VFR presolo maneuvers can be achieved with a ground trainer and visual presentation which provides the pilot pitch, roll, and yaw information with respect to a horizontal and directional referent. Attributes of the pilot ground trainer which contributed to positive transfer are defined. Maneuver situations which resulted in zero training transfer during aircraft validation flights are detailed. The characteristics deemed necessary for ground trainers to be effective for primary maneuver training are defined.

NA-73-16

EVALUATION OF IMPROVED QUANTIZER DETECTOR MODIFICATION TO THE PRODUCTION  
COMMON DIGITIZER

Howard L. McFann and William C. Swanseen

Interim Report, May 1973 54p.

(RD-73-54) (AD 761 116)

A quantizer detector modification was installed in the Production Common Digitizer AN/FYQ-47 located at the Elwood, New Jersey, National Aviation Facility Experimental Center long-range radar site. The purpose of the modification was to improve the search target detection capabilities of the digitizer, particularly in radar clutter environments. This was accomplished by providing adaptive feedback loops in the quantizer and improving the Automatic Clutter Eliminator (ACE) logic circuitry. A series of element and subsystem tests were conducted to compile data for use in comparing the operational performance of the digitizer with and without the improved circuits. Test results indicate that the improved equipment effectively: maintains control of the noise probability over a 60 dB radar log receiver dynamic range; increases target detection capability in clutter; and regulates false alarm rates resulting in a minimum activation of the ACE total blank functions. It was concluded that the modification significantly increased the see-through-clutter capability of the Production Common Digitizer (PCD).

NA-73-19

DC-9 SAFE BOMB LOCATION STUDY

R. E. Darling

Final Report, January 1973 p.162

(RD-72-88) (AD 908 714L)

The DC-9 commercial aircraft structure and systems are reviewed to determine the optimum location to place a discovered explosive device for the best chance of survival of the aircraft and minimization of casualties. The damage that would be caused by the explosion and the structural residual strength are determined.

The study revealed that the best place to put the bomb to do the least damage would be on the ventral stairs for those airplanes so equipped. On other DC-9 airplanes, the bomb should be put in the tail cone.

NA-73-23

TEST AND EVALUATION OF A SYSTEM FOR PRECISE TIME-DISSEMINATION USING DME (VORTAC) SYNCHRONIZATION

Vincent J. Luciani

Final Report, August 1973 75p.

(RD-73-104) (AD 766 897)

This report covers the test and evaluation of an experimental system designed to provide precise time to aircraft via a DME (VORTAC) ground station modified to utilize a Cesium-beam atomic clock for a time base. Data acquired from a flight test at NAFEC demonstrated the feasibility of this time-dissemination concept for application in time/frequency collision avoidance systems. The standard deviation of time-dissemination error was found to be 0.47 microseconds. DME one-way ranging capability was also demonstrated, wherein ranging accuracy of a modified airborne DME operated one-way averaged 0.1-nmi difference over that of an unmodified airborne DME in conventional two-way operation.

NA-73-27

AN INVESTIGATION OF ATC PROCEDURES FOR IFR APPROACHES TO TRIPLE PARALLEL RUNWAYS

William Crimbring, G. Errol Porter

Final Report, May 1973 19p.

(RD-73-37) (AD 760 634)

This activity was conducted to investigate air traffic control (ATC) procedures applicable to the conduct of simultaneous instrument flight rules (IFR) approaches to a set of three parallel runways. A dynamic simulation was conducted to examine the various aspects of such an operation, including ATC procedures, monitoring requirements, general controller workload limits, and a comparison of the effect of greater and lesser percentages of Mode C-equipped aircraft on monitoring procedures. Results show that the concept of conducting simultaneous instrument approaches to a set of triple parallel runways is feasible using standard ATC procedures and separation standards (except on the final approach course).

NA-73-28

INVESTIGATION OF SITE COVERAGE AND AIRPORT, CHICAGO, ILLINOIS, ENROUTE RADAR  
BEACON TEST SITE

George F. Spingler

Interim Report, April 1973 61p.

(RD-73-49) (AD 761 562)

A temporary beacon test site was installed adjacent to the Chicago, Illinois, O'Hare Airport and operational tests were conducted to determine its suitability for possible use as a future enroute radar beacon site. Photographic data were collected using "targets-of-opportunity" flying within the coverage area of the test site. The data were analyzed at NAFEC to determine the extent of the radar beacon coverage and further scrutinized to uncover any anomalies which might derogate the operation of an enroute radar beacon site installed at the test location. As a result of the initial data analysis, flight tests were conducted in the vicinity of the O'Hare Enroute Radar Beacon Test Site using a NAFEC jet aircraft. The NAFEC flight tests confirmed the originally-suspected problem areas and provided additional justification for linking the anomalies to the vertical radiation pattern of the standard radar beacon directional antenna. The total test effort showed that: (1) the procedure of using a temporary beacon test facility to determine coverage and problem area of future radar beacon sites was sound, and (2) that this procedure should be utilized whenever there is some question about the adequacy of the coverage that a future site might provide.

NA-73-30

A COMPARISON OF GENERAL AVIATION OCCUPANT RESTRAINT SYSTEMS

John Sommers, Jr.

Final Report, August 1973 20p.

(RD-73-114) (AD 766 024)

The majority of current general aviation aircraft are not equipped with upper torso restraint systems. Due to this, when an accident occurs, many severe and fatal injuries result from head impacts with surrounding passenger compartment structure and equipment. Also, as in the automobile, there is a tendency not to use shoulder-type restraints although they may be installed in the aircraft. To cope with this, the provision of an automatic activating airbag restraint system triggered by an impact force has been advocated. This report reviews the results of some of the early deceleration test work conducted on an airbag system. Follow-on static and dynamic tests of an automotive system experimentally tailored to general aviation aircraft are described. Test results which show attenuation of the upper torso deceleration levels and compared with tests of conventional systems are discussed. Some results of deceleration tests of restraint systems utilizing shoulder harness are also presented. A comparison of these results with those of the airbag tests indicate a nearly identical level of protection excepting that the airbag prevents flailing of the occupants' arms, whereas the shoulder harness does not. Static tests showed that inadvertent operation of the experimental airbag system tested could interfere with operation of the aircraft.

NA-73-32, I  
LIGHTNING EFFECTS ON GENERAL AVIATION AIRCRAFT  
J. A. Plumer, General Electric Company  
Final Report, October 1974 56p.  
(RD-73-98)

Typical design features of light aircraft were evaluated to determine their possible vulnerability to lightning and develop design guidelines for protective measures. From these evaluations and other related state-of-the-art technology, a set of engineering guidelines have been formulated to assist designers in making use of this technology to provide lightning protection for general aviation aircraft. This report presents these guidelines. The results of the experimental studies on which they are based are presented in a companion report.

NA-73-32, II  
LIGHTNING EFFECTS ON GENERAL AVIATION AIRCRAFT  
J. A. Plumer, General Electric Company  
Final Report, October 1973 56p.  
(RD-73-99) (AD 771 201)

To determine the actual lightning vulnerability of typical light aircraft systems and components, and demonstrate the required vulnerability assessment techniques, analyses and laboratory tests were performed on several typical light aircraft and some of their systems and components. This report describes the engineering and laboratory evaluation of component or system vulnerability.

NA-73-33  
DIGITAL SIMULATION FACILITY/SYSTEM SUPPORT FACILITY INTERFACE TESTS  
R. R. Reyers  
Final Report, July 1973 38p.  
(RD-73-67) (AD 763 138)

Over a period of 9 months, a series of tests was conducted to interface the Digital Simulation Facility (DSF) with the System Support Facility (SSF) at the National Aviation Facilities Experimental Center (NAFEC). Included were tests of the DSF performance, as well as tests of the hardware interface to the 9020 Computer, and the software interface to the NAS Model 3dl program. This report describes these tests and the results obtained.

NA-73-34  
THE MEASUREMENT OF THE DC-7 TRAILING VORTEX SYSTEM USING THE TOWER FLY-BY TECHNIQUE  
Leo J. Garodz, Nelson J. Miller, and David Lawrence  
Final Report, November 1973 374p.

This report describes the technique and presents the results of a series of full-scale flight tests performed at NAFEC in September 1971, in which the wing trailing vortices of the Douglas DC-7 airplane were investigated by flying the airplane at low altitude, upwind of, and in close proximity to a 140-foot instrumented tower. Tower instrumentation consisted of hot-film anemometers located at 4-foot interval and wind velocity and direction sensors. Vortex air flow visualization was by use

of colored smoke. The aircraft was tracked by the National Aviation Facilities Experimental Center's Phototheodolite Facility. The data consists of tangential velocity distribution plots, peak recorded velocity as a function of time, airplane configuration and wind; vortex vertical and lateral transport velocities and specimen time histories of the velocities recorded at individual sensors. The principal findings were: (1) Peak absolute velocity, associated with the vortex core, decays exponentially; (2) Vertical transport velocities of the vortices do not correlate well with those predicted by potential flow theory; (3) Lateral transport velocities correlate fairly well with values obtained from theory; and (4) The resolution possible with 4-foot spacing of the hot-wire anemometers is insufficient to precisely define vortex core size of the subject airplane.

NA-73-36

INVESTIGATION OF THE REFLECTED RADAR-BEACON REPLY PROBLEM AT THE NORTH PLATTE, NEBRASKA, EN ROUTE RADAR SITE

George F. Spingler

Interim Report, April 1974 69p.

(RD-74-68) (AD 780 380)

The National Aviation Facilities Experimental Center (NAFEC) conducted an investigation, at the request of the Central Region, at the North Platte, Nebraska, En Route Radar Site and the Denver, Colorado, Air Route Traffic Control Center to determine the cause of a split radar-beacon reply problem that existed in the system. It was concluded from this investigation that the terrain in the vicinity of the North Platte facility together with the radar beacon directional antenna that was installed at the facility were responsible for the split radar-beacon reply problem. An improved radar beacon directional antenna, that utilized the ARSR-2 radar reflector, was designed, fabricated and tested at NAFEC to reduce radar beacon radiations below the horizon. This antenna was afterward installed and tested at the North Platte Facility. The results of the testing at the North Platte facility showed that the new antenna design had eliminated the split radar-beacon reply problem. From the results of the testing at North Platte, it was concluded that this antenna could be used at other en route radar facilities to eliminate existing propagation problems.

NA-73-40

AIR TRAFFIC CONTROL/COLLISION AVOIDANCE SYSTEM INTERFACE SIMULATION - PHASE II

G. Jolitz

Final Report, November 1973 193p.

(RD-73-140) (AD 771 185)

A second phase of dynamic simulation was conducted at the National Aviation Facilities Experimental Center to further investigate the nature and extent of interaction between the air traffic control (ATC) system and an airborne collision avoidance system (CAS). The results of an exploratory phase of simulation may be found in Interim Report No. FAA-RD-72-10, "ATC/CAS Interface Simulation - Exploratory Phase" dated March 1972. Objectives of the Phase II simulation were threefold: (1) to investigate the impact on ATC when the preemptive CAS diverted an equipped aircraft into an encounter with an unequipped aircraft, (2) to investigate the effectiveness of a strategy for switching the CAS threat detection from full system mode to landing mode, and (3) to explore the three-way interface between a

proposed general aviation version of the CAS, the commercial CAS and the ATC system. The simulated ATC environment was a high-density terminal area which provided for simultaneous approaches to parallel runways. The CAS threat detection logic was modeled after a design which was developed by a technical working group under the auspices of the Air Transport Association (ATA). The general aviation CAS was a scaled down but compatible version of the ATA system. Results of the simulation showed that the mode-switching strategy generally had the effect of reducing ATC/CAS interaction to a level where its effect was below the controllers' threshold of perception. No encounters were observed where the CAS diverted an equipped aircraft into the path of an unequipped aircraft. It was concluded that the degree of ATC/CAS interaction was strongly influenced by the demand density and by ATC procedures.

NA-73-41

COMMON DIGITIZER (FYQ-47) RADIO FREQUENCY INTERFERENCE MEASUREMENTS AT THE ELWOOD, N. J., LONG RANGE RADAR SITE

George C. Apostolakis, John J. Fisher, Jr.

Interim Report, October 1973 56p.

(RD-73-123) (AD 767 965)

Operating Long Range Radar Sites (LRRS) have reported that the Common Digitizer (CD) interferes with the Back-Up Emergency Communications (BUEC) equipments when the CD doors are OPENED for maintenance purposes. This problem was investigated by NAFEC at the LRRS located at Elwood, New Jersey. The investigation consisted of making Radio Frequency Interference (RFI) field strength measurements at various locations, both inside and outside the LRRS building as well as on the roof and radome catwalk. The measurements were made for various combinations of equipments being on with the CD doors both OPENED and CLOSED. It was determined that the CD with doors OPEN is the major source of RFI. The radiating source within the CD was traced to its core memory. With the CD doors CLOSED, RFI is reduced to negligible levels; furthermore, the roof of the building reduces the CD RFI to negligible proportions.

NA-73-43

AIRCRAFT FUEL SYSTEM TESTS WITH GELLED FUEL-FLOWMETERS CALIBRATION, FUEL BOOST PUMP AND JETTISON TESTS

Joseph A. Avbel

Final Report, November 1973 27p.

(RD-73-188) (AD 770 251)

The feasibility of using gelled fuel (nominal 250 centipoise viscosity) with full scale aircraft fuel system components was investigated. Tests indicated that turbine-type flowmeters are suitable for measuring flow rates with accuracies of 1 percent. Jettison and fuel feed operations were conducted using a B-57 wing fuel tank. Approximately 3 percent more gelled fuel than JP-5R remained in the tank after "emptying" the tank in both boost pump and jettison tests. Flow rates and times to "empty" the tank were significantly poorer with the gelled fuel when compared to the results obtained with the JP-5R fuel. The gelled fuel tested is considered unsatisfactory because of its instability in storage, causing wide variations in viscosity.

NA-73-48

TECHNICAL EVALUATION OF WEATHER CLUTTER FEASIBILITY MODEL

Ronald S. Bassford

Interim Report, August 1973 66p.

(RD-73-85) (AD 766 007)

An ASR-5 Weather Clutter Feasibility Model was developed and evaluated to determine its capability to provide Air Traffic Controllers with a weather display (clutter free) of air traffic and a contour depiction of weather detected by radar. The technical tests included the determination of technical characteristics of each of four modifications (narrow transmitter pulse width, noncoherent moving target indicator, dual frequency diversity, and logarithmic/fast time constant) which comprised the weather rejection portion of the system along with their capabilities to provide clutter rejection and target detection in weather. The four modifications were then tested in unison to determine the system's overall capability. The weather channel portion of the the equipment was tested to determine its capability to provide weather clutter formatting in the form of isoamplitude contours. The results of the test demonstrated that the Weather Clutter Feasibility Model does not effectively perform the designed functions of weather clutter rejection and weather clutter contouring. Its capability to provide weather clutter contouring ranges from good for high-level well-defined weather cells to poor for low-level scattered cells. The equipment is not acceptable for use in the air traffic control system.

NA-73-49

DIGITIZER PERFORMANCE UNDER CONDITIONS OF LINEAR AND CIRCULAR ANTENNA POLARIZATION

Martin M. Holtz

Interim Report, August 1973 24p.

(RD-73-105) (AD 766 023)

This report describes the test methods employed and the results obtained during a test and evaluation that was conducted to determine digitizer performance under conditions of linear and circular antenna polarization. Technical tests were conducted to determine system performance for conditions of linear and circular polarization of the NAFEC ASR-5 Antenna. The tests were performed for inputs derived from permanent echoes, small test aircraft, and test targets within weather clutter. It was concluded that a significant increase in target detection within weather clutter was achieved when employing circular polarization, with little degradation in detection of targets within a clutter-free environment. In most cases the number of false targets within a weather clutter environment was reduced when employing circular polarization. Therefore, improved performance of a radar processor was achieved when employing circular polarization under conditions of weather clutter returns.



NA-73-50

DETECTION OF SMALL AIRCRAFT BY A TERMINAL RADAR PROCESSOR

Marvin Holtz

Interim Report, August 1973 15p.

(RD-73-106) (AD 766 025)

This report describes the test methods employed and the results obtained for tests conducted to determine detection of small aircraft by a terminal radar processor. Flight tests consisting of radials, over-the-station passes, and orbits were conducted using a Piper Cherokee 180, a Cessna 172, and a Piper Super Cub. The radar returns from each of the aircraft were processed by the Radar Video Processor (RVD-3) and percent detection as a function of range and altitude was obtained. It was concluded that: (1) good detection of the aircraft was achieved with the limiting factor being aircraft altitude (at the upper altitude limits of the terminal airspace, a small aircraft is detectable out to approximately 50 to 55 nautical miles;) (2) there is no defined "Cone of Silence" within the altitude limits of a terminal environment; (3) MTI video has a tendency to degrade target detection.

NA-73-51

THE 1972 LOS ANGELES BASIN STANDARD AIR TRAFFIC MODEL

Francis M. Willett, Jr.

Final Report, September 1973 52p.

(RD-73-90) (AD 767 075)

This report describes the methodology used in the construction of a three-dimensional aircraft movement operating in the Los Angeles Basin Area. From data obtained, the Los Angeles Basin Air Traffic Model of 1972 was constructed. The model contains approximately 80-percent VFR flight operations, and represents a particular time period of nonpeak aircraft operations which occurred during a 3-hour period on the 20th of August 1972. The purpose of the traffic sample is to develop a standard model to test future air traffic systems and equipment. Since most air traffic operation models are generally made from IFR-controlled operations, this is the first of a series of air traffic models that include both IFR and VFR operations. The following list refers to related documents: Report Numbers FAA-RD-73-86; FAA-RD-73-87-I; FAA-RD-73-87-II; FAA-RD-88; and FAA-RD-73-89.

NA-73-54

FIELD EVALUATION OF ARTS II B (TRACAB)

Robert A. Clark and James F. Akers

Interim Report, October 1973 45p.

(RD-73-119) (AD 768 203)

A programmable ARTS II B, non-tracking, beacon alphanumeric system was installed in a TRACAB configuration in a live air traffic control tower environment. Operational suitability and techniques to be used in the automation program for low-density terminal/towers were evaluated. The system was evaluated over a six-week period through collection of subjective data obtained from controller questionnaires. It was concluded that while suitable for application in a TRACAB environment and compatible with the controller, extensive modification to both display subsystem and software were required to improve its usefulness.

NA-73-55

SYSTEM INTEGRATION AND SYSTEM SHAKEDOWN TESTS, NAS ENROUTE STAGE A MODEL A3dl

Joseph Levy and Victor Crawford

Final Report, October 1973 74p.

(RD-73-135) (AD 768 202)

A series of tests of the National Air Space (NAS) Enroute Stage A Model A3dl System were conducted over a period of 7 months in a total system environment using simulated and live radar inputs to evaluate the total system capability to accomplish the air traffic control task and to provide guidance for conduct of System Integration and System Shakedown tests at field facilities. This report describes these tests and the results obtained.

NA73-56

EVALUATION OF A TERRAIN PROXIMITY WARNING SYSTEM (DOWNWARD LOOKING RADAR) FOR POSSIBLE ENHANCEMENT OF FLIGHT SAFETY

Jack J. Shrager

Interim Report, August 1973 26p.

(RD-73-134) (AD 766 590)

A review of all literature and available test results of an airborne independent altitude monitor based on radio altitude information was undertaken. Results indicated that limited flight safety enhancement is attainable by use of such a device.

NA-73-57

INVESTIGATION OF RADIO-FREQUENCY INTERFERENCE TO THE BACKUP EMERGENCY COMMUNICATION EQUIPMENT

George Apostolakis, John Riley and Arthur Moss

Interim Report, December 1973 81p.

(RD-73-163) (AD 771 234)

NA-73-59

X-BAND TERMINAL RADAR TEST AND EVALUATION

Ronald S. Bassford

Final Report, January 1974 70p.

(RD-73-159) (AD 774 677)

An X-band radar system was evaluated to determine its capability to perform as an Airport Surveillance Radar. Included in the investigation were equipment tests to determine basic system parameters, flight tests to determine system coverage with respect to air traffic control requirements, tests to determine the capabilities of the system processor, and an operational evaluation performed by Van Nuys, California Air Traffic Control personnel.

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NA-73-60

NAS ENROUTE STAGE A SYSTEM ENGINEERING AND ANALYSIS INVESTIGATION OF SYSTEM PROBLEMS RADAR DATA LOSS

Harry T. Morgan, Jr.

Final Report, January 1974 19p.

(RD-73-183) (AD 773 444)

A series of special engineering tests, designed specifically to evaluate NAS Model 3dl capability to reliably process and display radar data without loss, was conducted at the National Aviation Facilities Center (NAFEC) employing the Digital Simulation Facility and the System Support Facility. This report describes these tests and the results obtained.

NA-73-61

INFLATABLE RESTRAINT CONCEPT FOR GENERAL AVIATION AIRCRAFT

Richard W. Carr and Norman S. Phillips

Final Report, May 1973 117p.

(RD-73-3) (AD 762 601)

This report documents a program that investigated inflatable restraint design criteria and developed an airbag restraint system for use in a general aviation aircraft. The program required three phases of effort which were data collection, establishment of design goals, and concept development. The first phase consisted of collecting data on crash acceleration profiles, inflatable restraints, energy attenuation criteria, and airframe dimensions. With this information and available human tolerance data, it was possible to develop analytical models of the seated occupant and airbag restraint, which were used to determine the design goals for inflatable occupant restraint, that could be used in general aviation aircraft. Once the design goals were established, airplane cabin dimensions and inflatable system performance specifications were used to develop an inflatable restraint concept for general aviation aircraft.

NA-73-62

A FEASIBILITY STUDY AND PRELIMINARY EVALUATION OF THE USE OF A BIASED GLIDE SLOPE TECHNIQUE FOR NOISE ABATEMENT APPROACH

Robert H. Pursel

Final, November 1973 34 P.

(RD-73-153) (AD 769 269)

A feasibility study and a preliminary evaluation of the technique of conducting noise abatement approaches by using a biased glide slope deviation signal were conducted at the National Aviation Facilities Experimental Center. Manual approaches using a flight director system and automatic approaches using an automatic flight control system were flown at angles up to 0.9 degrees above the commissioned glide slope angle. A ramp washout of the bias was used with the washout time constant and initiation altitude of the washout treated as variables. It was concluded that the average glide slope beam will allow a biased approach of about 0.7 degrees above the commissioned angle and that the technique is operationally feasible.

NA-73-63

AEROSPACE VEHICLE HAZARD PROTECTION PROGRAM; DETECTORS, MATERIAL, FUEL VULNERABILITY

John. H. O'Neill

Final, October 1973 64P.

(AD 7776 301)

Fire tests were conducted in a turbojet powerplant installation to determine the effectiveness of an Edison and a Honeywell Ultraviolet Fire Detection System. The four sensor units for each system were installed on the forward bulkhead of the engine nacelle's accessory and compressor compartment (Zone II) and provided surveillance aft to the firewall. Fires having fuel-flow rates of 0.04 and 0.13 gallons per minute were initiated about 12 inches forward of the firewall at several locations around the periphery of the engine.

Both systems provided adequate detection of the 0.13 gallon per minute fires, but generally there was limited detection of the small 0.04 gallon per minute fires, depending on the fire location. Both systems provided rapid response time to fires within the range of 0.2 to 1.0 seconds after the fuel-to-fire was released. In this test installation, the peripheral disposition of the sensor units on the forward bulkhead provided overlapping coverage by most units.

A study of flammability and smoke generation characteristics was performed on different types of litter pads and pillows. These items were subjected to the following tests; Horizontal Test Method, ASTM E-162 and Smoke Measurement Test Method, ASTM STP No. 442.

Fire resistance tests in a standard 2,000°F flame-test environment were conducted on two flexible self-sealing low pressure Aeroquip hoses and an aluminized asbestos-faced flexible fiberglass cloth. One hose was coated with an AVCO Corp. intumescent paint identified as Flexible Flame Arrest; the other was uncoated. The hoses were tested while temperature-controlled oil was pumped through the hose.

An investigation of the vulnerability of JP-4 and JP-8 fuel, contained in a fuel tank, to ignition by incendiary gunfire was made. Tests were conducted utilizing a horizontal, liquid phase test article, either JP-4 or JP-8 fuel and varying the following parameters: (1) standoff distance between the fuel cavity and the test article skin, (2) volume of the standoff cavity, (3) ventilation rate in the standoff space, and (4) airflow over the test article surface. A series of tests was also conducted with an elevated fuel tank. This test configuration permitted fuel to vapor penetration by the incendiary projectile. These tests were conducted with either JP-4 or JP-8 fuel and simulated airflows of 0, 90, 150, and 390 knots over the test article.

NA-73-64

#### VISUAL APPROACH SLOPE INDICATOR (VASI) IMPROVEMENTS

Thomas Paprocki

Final, July 1973 8 P.

(RD-73-96) (AD 763 562)

This final report outlines, briefly, the major work accomplished during recent years in a continuing effort to improve and update Visual Approach Slope Indicator (VASI) equipment and systems being utilized at various category airports within the United States. Results and conclusions arrived at through a number of VASI evaluation projects are cited in so far as they pertain to the following areas of VASI development and investigation: (1) Suitability of VASI for Long-Bodied Aircraft Use; (2) Techniques for Reducing VASI Lateral Beam Coverage; (3) Visual Approach Multiple Slope Indicator (VAMSI) Concept Development; and (4) VASI Signal Transition Zone and Color Modifications. Reference to previous and interim reports providing detailed information about each of the subject areas is provided.

NA-73-68

A SUMMARY OF HELICOPTER VORTICITY AND WAKE TURBULENCE PUBLICATIONS WITH AN ANNOTATED BIBLIOGRAPHY

Jack J. Shrager

Final, May 1974 187 P.

(RD-74-48) (AD 780 053)

A review of all literature published since 1964 relating to helicopter vortex systems and wake turbulence was made. The results of this review are evaluated and summarized, and conclusions are drawn relative to that review. The documents are grouped in general categories, and this is further supplemented by an annotated bibliography and authors index. Also incorporated in the review is a comparative analysis of rotary-wing versus fixed-wing circulation intensity time-history.

NA-73-69

A STUDY OF THE DECOMPOSITION PRODUCTS OF POLYURETHANE FOAM RELATED TO AIRCRAFT CABIN FLASH FIRES

Maya Paabo and J. J. Comeford

Final, July 1973 39 P.

(RD-73-46) (AD 759 864)

A laboratory model of a flash fire cell using a high voltage arc as an ignition source was assembled and tested. The cell is designed to pyrolyze the sample in air while measuring the time of onset of a flash fire and simultaneously allowing withdrawal of gas samples for analysis. Some of the low molecular weight products produced from the pyrolysis of flexible polyether type urethane foams were identified. The flash fire cell was used to compare the flash fire potential of polymers of potential interest to the aircraft industry. Studies of the role of smoke in flash fire produced in the pyrolysis of flexible urethanes were undertaken. Flash fires in the cell were recorded on 16 mm motion picture film.

NA-73-70, I

PHYSIO-CHEMICAL STUDY OF SMOKE EMISSION BY AIRCRAFT INTERIOR MATERIALS - PART I PHYSIOLOGICAL AND TOXICOLOGICAL ASPECTS OF SMOKE DURING FIRE EXPOSURE

I. N. Einhorn

Final, July 1973 86 P.

(RD-73-50, I) (AD 763 602)

A concise review of the physiological and toxicological aspects of smoke during fire exposure has been presented. This report attempts to elucidate the parameters, both chemical and physical, which lead to smoke development, and subsequently, light obscuration, during their pyrolysis and combustion.

Analysis of recent fire statistics covering losses during the past decade has been compiled and incorporated into the report.

Various laboratory test procedures, both small-scale and large-scale, have been summarized and a critique presented outlining their usefulness and problems encountered in interpretation of results obtained using these test procedures.

A review of the physiological and toxicological parameters affecting survival of humans during fire exposure is given. Consideration is directed toward the specific hazards encountered during aircraft accidents involving fire. Recent reviews of the medical literature pertaining to fire injury is discussed in detail.

NA-73-70, II

PHYSIO-CHEMICAL STUDY OF SMOKE EMISSION BY AIRCRAFT INTERIOR MATERIALS - PART II RIGID- AND FLEXIBLE-URETHANE FOAMS

I.N. Einhorn, M. D. Kanakia, and J. D. Seader

Final, July 1973 143 P.

(RD-73-50, II) (AD 763 935)

A study was conducted by personnel of the University of Utah's Flammability Research Center to determine the flammability characteristics and thermal degradation of urethane cellular plastics used in aircraft interiors.

Initially, model urethane polymers, representative of systems used in aircraft interiors, were prepared, and the effect of the chemical structure of isocyanates and polyols on performance during fire exposure were studied. A series of non-fire-retarded rigid-urethane foams was synthesized and evaluated to serve as the basis for further research directed toward the synthesis of fire-retarded systems. Following this, a series of fire-retarded foams was synthesized incorporating reactive and non-reactive fire retardants in various concentrations.

The flammability characteristics of these cellular plastics were evaluated using test methods for the ease of ignition, flame propagation, fire endurance, smoke emission, and oxygen index as criteria.

Based on the information obtained, a series of optimized rigid foams, which incorporated reactive and auxiliary fire retardants, was prepared and evaluated. The optimized rigid foam systems exhibited substantial improvements in the ignition, flame propagation, and fire-endurance characteristics, and a moderate reduction in the tendency to produce smoke.

Similar studies were carried out using formulations representing flexible urethane foams. Improvement in those properties governing ignition and flame propagation were realized at the expense of increasing the smoking tendency of these flexible systems.

NA-73-73

THE MEASUREMENT OF THE BOEING 747 TRAILING VORTEX SYSTEM USING THE TOWER FLY-BY TECHNIQUE

Leo J. Garodz, David Lawrence, and Nelson J. Miller

Final, June 1974 233 P.

(RD-73-156) (AD 782 046)

The characteristics of the trailing vortex system of the Boeing 747 airplane have been investigated by the National Aviation Facilities Experimental

Center (NAFEC), Atlantic City, N. J., during a series of flight tests conducted in September and October 1972. This investigation is part of a long-term program, started in February 1970 with flight tests conducted by NAFEC at the Atomic Energy Commission site at Idaho Falls, Idaho, devoted to the study of the overall wake turbulence problem. The present tests were conducted using improved flow measurement and meteorological instrumentation, permitting greater resolution than had been possible in earlier testing. Principal findings were that the peak tangential velocity decays as the reciprocal of the square root of the time elapsed since vortex generation; that the peak velocity is unaffected by the throttling back of the adjacent outboard engine; and that the lateral transport velocities correlate quite well with theory. Vortex descent rates did not correlate with theory, being up to three times greater than theoretical values. It was further determined that the velocity distribution in the Boeing 747 trailing vortices is strongly affected by the wing flap setting. At small settings, the vortex core diameter is small and peak tangential velocities are high, and as the flap deflection is increased, the core diameters increase and peak velocities diminish.

NA-73-75

EVALUATION OF LARGE SCREEN DISPLAY IN THE AUTOMATED OCEANIC ATC ENVIRONMENT

Anthony J. Spingola and Robert L. Giordano

Final, October 1973 43 P.

(RD-73-136) (AD 768 839)

Tests were conducted utilizing a representative traffic sample within an ocean sector incorporating the northern half of the Oakland Flight Information Region (FIR). The majority of the test subjects were Oakland Air Route Control Center (ARTCC) controllers; however, National Aviation Facilities Experimental Center (NAFEC), Anchorage ARTCC, and Honolulu ARTCC were represented. The Large Screen Display (LSD) was evaluated as a subsystem of the Oceanic Air Traffic Control Experimental Automation System. All test subjects controlled the same traffic sample and performed all of the interactions appropriate to a normal ocean sector operation. The LSD was used to portray all the required oceanic ATC data. A questionnaire was completed by each test subject immediately after completion of each test. There were totals of 12 days testing during 3 separate weeks and 20 test subjects. There was no intention to evaluate the automated functions as they existed in the experimental system, nor was any consideration given to the cost or technical aspects of this LSD. Analysis of controller questionnaire responses indicates generally that the LSD was an acceptable method of displaying information; however, an individual cathode ray tube was preferred. There were on pertinent applications of the LSD recommended that were not included in the test series. It is possible, however, that there may be LSD applications in other than the oceanic ATC environment, particularly where group viewing is a requirement.

NA-73-77

OPERATIONAL EVALUATION OF THE ARTS II RADAR ALPHANUMERIC DISPLAY SUBSYSTEM (RADS)

James F. Akers and Robert A. Clark

(RD-73-149) (AD 768 698)



A programmable, nontracking beacon Automated Radar Terminal System (ARTS II A) was installed in a TRACON configuration at the National Aviation Facilities Experimental Center. The operational suitability of the Radar Alphanumeric Display Subsystem (RADS) was evaluated. The RADS displays were evaluated over a 2-week period through the collection of subjective data obtained from controller questionnaires. It was concluded that the RADS consoles are suitable for use in air traffic control facilities. Modifications to the FOCUS control, MAP ILLUM control, A/N GAIN control, and Data Block Offset Switch are recommended.

NA-73-78

ADVANCED FLIGHT CONTROL AND ELECTRONIC DISPLAY SYSTEMS FOR ALL-WEATHER FLIGHT OPERATIONS: A LITERATURE REVIEW AND BIBLIOGRAPHY

Jack J. Shrager

Final, June 1974 141 P.

(EM-74-12) (AD 783 987)

A review of all literature published since 1967 relating to aircraft flight controls and displays was made. Special emphasis was placed on the contents of those documents as they related to the all-weather landing and takeoff operational envelope. The results of this review are evaluated, summarized, and conclusions drawn. This is supplemented by an annotated bibliography and author's index.

NA-73-79

EVALUATION OF THE STRUCTURAL INTEGRITY OF AN AIRCRAFT LOADING WALKWAY UNDER SEVERE FUEL-SPILL FIRE CONDITIONS

George B. Geyer, Lawrence M. Neri and Charles H. Urban

Final, October 1973 105 P.

(RD-73-144) (AD 772-476)

A full-scale fire test was conducted to determine the capability of an aircraft loading walkway to provide a safe emergency egress route for passengers from an aircraft when it is exposed to severe fuel-spill fire conditions in terms of structural integrity and of maintaining survivable environmental conditions within the structure. Fire exposure of the walkway indicated that the structural integrity of the walkway maintained throughout the 10 minute fire exposure period and that the most serious problem confronting passengers passing through the tunnel would be caused by smoke and the pyrolysis of the underside of the plywood flooring adjacent to the corrugated steel shell. Small-scale laboratory tests of modified floor panels indicated that by employing thermally stable load-bearing materials the quantity of pyrolysis products and smoke can be controlled within the walkway.

NA-73-80

TEST AND EVALUATION OF A CONFLICT ALERT CAPABILITY FOR THE NAS ENROUTE SYSTEM

Joseph Levy and Frederick Ranger

Interim, February 1974 19 P.

(RD-74-15) (AD776 145)

A series of tests of a conflict alert capability was conducted over a period of 4 months to evaluate the operational suitability of a system which alerts radar controllers to potential violation of radar separation standards. These tests were conducted in a beacon only high-altitude airspace environment with simulated digital target data. This report describes these tests and the results obtained.

NA-73-83

TEST AND EVALUATION OF THE LEVEL 1 BEACON AUTOMATED RADAR TERMINAL SYSTEM (ARTS III)

Martin Holtz

Interim, January 1974 125 P.

(RD-73-182) (AD 773 711)

This report describes the test and evaluation that was conducted to determine the performance characteristics of the Level 1 Beacon Automated Radar Terminal System (ARTS III). A test bed was established to record ARTS III beacon target replies and reports on digital tape. Computer programs were prepared to process the digital tapes and to provide statistical data defining system performance. Technical tests were conducted to determine the characteristics of the ARTS III quantizer, bracket and code pulse recognition logic, and garble detection logic. In addition, the performance of the software code validation and target detection algorithms was established. Operational tests were conducted to determine the effect that a storage tube defruiter had on system performance. The test and evaluation program established the baseline standards of performance for the ARTS III System. This information will be used in development of a prototype level 2 beacon-processing subsystem. It was concluded that the pseudoleading edge detector does not operate in accordance with design specifications. The ARTS III System should operate with a leading edge criterion of two, and a minimum hit count of four and five for Mode 3/A and 3A-C replies, respectively. Additionally, performance of the system was improved by processing undefruited video as opposed to defruited video; however, the beacon input-processing algorithm required design modifications to improve system efficiency for processing undefruited video.

NA-73-84

EVALUATION OF A PORTABLE PHOTOMETER TO MEASURE THE LIGHT OUTPUT OF INSTALLED IN-PAVEMENT LIGHTING FIXTURES

Raymond E. Johnston and E. Leon Reamer

Final, November 1973 13 P.

(RD-73-157) (AD 769 935)

The purpose of this effort was to determine the suitability of a portable photometer to rapidly measure the light output of inset runway lights. The work involved: (1) Laboratory measurements to compare the experimental unit with a standard laboratory photometer; (2) Field measurements of inset lighting by a team of technicians; and (3) Analysis of the photometer construction. The result of the tests indicated that the portable photometer was adequate for the measurement of L-850A inset lights, but that some minor changes should be incorporated in the final design to make the unit more rugged and to permit measurement of more than one fixture type.

NA-73-85

AUTOMATED RELIABILITY ASSESSMENT PROGRAM

John J. Wojciechowicz

Final, Report, April 1974 37 P.

(RD-74-16) (AD 778 935)

The Systems and Equipment Engineering Branch, ANA-140, has developed the Automated Reliability Assessment Program (ARAP) for evaluation of Federal Aviation Administration (FAA) equipments and systems. The ARAP is a set of Procedures and computer programs used to reduce and analyze failure/maintenance data. In addition to reliability parameter estimation, related failure/maintenance characteristics are analyzed including failure modes, maintenance manhours, part replacement/failure rates, and part disposition. The ARAP has been in operation over the past two years and significant benefits in terms of assessment quality, manpower cost, and completion time, have been derived. It is recommended in the report that the ARAP be utilized to support reliability/maintainability activities at the National Aviation Facilities Experimental Center (NAFEC) and be considered for FAA-wide implementation.

NA-73-86

ULTRAVIOLET AND NEAR-INFRARED SPECTRAL ANALYSIS OF A BURNER-CAN BURN-THROUGH FLAME

Richard Hill

Final, November 1973 26 P.

(RD-73-154) (AD 769 934)

The near-infrared and ultraviolet spectrum of a burner-can burn-through flame was analyzed using a J47 engine to produce the burn-through flame. Charts of the power output of the flame in the near-infrared and ultraviolet were produced for various engine power settings.

NA-73-87

THE INFLUENCE OF ENGINE-DUCTED BY-PASS AIR ON A BURNER-CAN BURN-THROUGH FLAME

Richard Hill

Final, November 1973 25 P.

(RD-73-155) (AD 771 102)

Tests were run to determine the effect of by-pass air flow on a burner-can burn-through flame. A simulator was developed to produce a burn-through flame external of a J-57 engine. Bleed-air from a J-57 was ducted and used as by-pass air during testing. Temperatures of the outer duct wall were monitored. A large decrease in temperature was noted with air flow through the by-pass duct.

NA-73-89

THE MEASUREMENT OF THE BOEING 727 TRAILING VORTEX SYSTEM USING THE TOWER FLY-BY TECHNIQUE

Leo J. Garodz, David Lawrence, and Nelson Miller

Final, August 1974 231 P.

(RD-74-90) (AD 786 569)

The results are presented of a series of low altitude (100-300 feet above ground level) flight tests performed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, in which the trailing vortices of the Boeing 727 airplane were investigated, using a 140-foot tower instrumented with air velocity, direction, temperature, and humidity sensors. Flow visualization was also employed, using colored smoke streams and film records made. The airplane was tracked by the NAFEC Phototheodolite Facility. The data presented consists of plots of vortex tangential velocity distribution, peak tangential velocity as a function of time, airplane configuration, windspeed, and airplane altitude in proximity to the tower, vortex descent rates, lateral transport velocities, and specimen time histories of the velocities measured by individual sensors. Principal findings were that: (1) Within the time scale of the experiment (vortices reached the tower 5-120 seconds after generation, depending on the separation from the tower and ambient windspeed), the decay envelope of the peak velocity conforms to the equation  $V_{\theta_{max}} = 1100t^{-1/2}$ , (2) Little or no change in vortex velocity distribution with airplane flight configuration can be detected. At all times, the vortex cores were found to be small - on the order of 2 feet in diameter, and the only significant timewise variation in the vortices was the decay of the peak velocity, (3) The lateral transport velocity of the vortices is independent of airplane flight configuration and its mean value was approximately equal to the crosswind velocity component measured at the tip of the tower. The absolute peak recorded tangential velocity, 260 ft/s, was found in an upwind vortex, landing configuration.

NA-73-90

MAN/MACHINE RELATIONSHIP IN NATIONAL AIRSPACE SYSTEM: PLAN VIEW DISPLAY POSITIONING

Richard Sulzer and Gloria Karsten

Interim, March 1974 35 P.

(RD-74-27) (AD 776 675)

The present investigation was an attempt to determine (1) the best angle that the Plan View Display (PVD) may be inclined while still permitting efficient operation with shrimpboats, (2) the properties of a feasible

shrimpboat that will not slide so much as to produce loss of association with the target when used at the proposed angle of elevation, and (3) the properties of a feasible add-on device for fixing the PVD at the angle proposed. Several shrimpboat designs were fabricated and tested at 20°, 25°, and 30° PVD inclinations, both in ideal conditions and in a simulated control situation with air traffic controllers. Shrimpboat model F, arrow-shaped, approximately 1 3/4 inch by 1 inch and 1/16 inch thick, standing on four dabs of silicone, showed best adherence (least slip). The more conventional model A, wedge-shaped, smaller but thicker, was preferred by controllers, but this model was the worst in slip tests. Only at the least steep PVD position was the model A stable. At 25° all shrimpboats except A were satisfactory in stability; hence, the 25° angle was recommended for the PVD. A simple extension for the leg position bumper was designed and tested to produce the change from a "horizontal" PVD position, actually 7°, to the recommended 25° slant.

NA-73-91

METHODOLOGY AND COMPUTER ANALYSIS FOR DETERMINING VOR/DME AND DME/DME AREA NAVIGATION ERRORS

Harry Sorensen

Final, February 1974 74 P.

(RD-73-208) (AD 776 714)

A computer analysis of VOR/DME and DME/DME area navigation is reported. The analysis includes three-dimension error models and an automated method of selecting the optimum stations to support an area navigation route structure. It is concluded that the computer program presented is useful for determining optimum stations to support an area navigation route. Additionally, certain subroutines can be used without the full analysis program to perform line-of-sight and geodetic calculations.

NA-73-92

TEST REPORT - RADIOFREQUENCY INTERFERENCE/  
ELECTROMAGNETIC INTERFERENCE MEASUREMENTS  
LOS ANGELES AIR ROUTE TRAFFIC CONTROL CENTER

Margaretta V. Stone

Final, Report, March 1974 270 P.

(RD-74-11) (AD 776 961)

This report describes electromagnetic interference tests at the Los Angeles Air Route Traffic Control Center (ARTCC), Palmdale, California. Measurements included radiated and conducted emission from the automated system and non-automated equipments, and radiated and conducted susceptibility of the automated system. Conducted and radiated electric and magnetic field emission from most automated system equipments exceeded MIL-STD-461A. Most automated system equipments met the susceptibility limits of MIL-STD-461A. Exceptions were the PVD, NRKM, CLU, TD, I/OCE, DRG, FR-1800 recorder, M1 display, SCC and CTS receiver. It was concluded that the automated system is unlikely to be affected by electromagnetic interference generated within a typical ARTCC site, although radiated and conducted emission from the nonautomated equipment at the Los Angeles site exceeded MIL-STD-461A limits. It is recommended, however, that

the susceptibility of the PVD, NRKM, CLU, TD, I/OCE, and FR-1800 recorder be further investigated, and that system designers contemplating addition of new equipment to ARTCC sites consider the results of this test program.

NA-73-93

EVALUATION OF IDENTIFICATION BEACONS FOR AIRPORT EMERGENCY VEHICLES

Bret B. Castle

Final, January 1974 31 P.

(RD-73-196) (AD 773 445)

The purpose of this effort was to determine the effectiveness of several newly developed identification beacons for airport emergency vehicles. Fourteen different light bar configurations were tested on the National Aviation Facilities Experimental Center (NAFEC) airport during various environmental conditions and a human appraisal of the different combinations was performed for suitable airport use. The results lead to conclusions as to which signal characteristics are most effective for use within the aircraft movement areas of airports.

NA-73-94

ACCURACY TEST OF NAFEC INSTRUMENTATION RADAR

Vincent J. Luciani

Final, January 1974 20 P.

(AD 771 668)

The slant range and azimuth accuracy capability of the National Aviation Facilities Experimental Center's Extended Area Instrumentation Radar (EAIR) was conducted using photographic technique for establishing reference position. Accuracies, compensated for propagation effects, were found to be 48 feet in slant range, and 0.012 degrees in azimuth.

NA-73-95

AN EVALUATION OF A MICROWAVE RUNWAY PERSPECTIVE INDEPENDENT LANDING MONITOR SYSTEM

Robert H. Pursel

Final, February 1974 41 P.

(RD-73-201) (AD 774 658)

A Microwave Runway Perspective Independent Landing Monitor System was evaluated in flight test in a DC-7 aircraft at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey. The system utilized eight microwave transmitters spaced in a pattern along Runway 13. Passive airborne equipment received pulses from these transmitters and displayed the video on a head-up viewer. The system was found to be highly susceptible to multipath reflections which caused a rapid display jitter. This problem was greatly reduced by the addition to the airborne equipment of a signal smoother. It was also found that the accuracy of usage of the basic display was unacceptable and that aiding symbology would have to be added to the display to improve accuracy of usage.

NA-73-97

NETWORK TERMINAL EQUIPMENT, EXPERIMENTATION WITH ELECTRONIC SELECTION EQUIPMENT DIGITAL SEQUENCE DETECTOR

Charles G. Santora

Final, June 1974 74 P.

(RD-74-102) (AD 781 531)

This report deals with the implementation and evaluation of a digital sequence detector as a replacement for the teletypewriter mechanical "stunt box" in order to obtain more capacity for addresses and answerback; greater reliability; and easier, faster reprogramming and repair. This device is intended for service A, B, and C, and was found, in adapting and testing one unit at the National Aviation Facilities Experimental Center, to perform equally or better than the model 28 automatic send/receive teletypewriter stunt box it replaced satisfactorily for eight-level and for the polarity-reversing voltage, high-impedance operations.

NA-73-98

SIMULATED GROUND-LEVEL STOL RUNWAY/AIRCRAFT EVALUATION PHASE III TESTS

Roman M. Spangler, Jr.

Final, August 1974 49 P

(RD-74-960) (AD 783 749)

A De Havilland DHC-6 Series 100 Twin Otter was flown by five pilots of varied experience on 7.5° steep-gradient approaches onto a ground-level STOL runway. Forty (40) approaches and landings were accomplished using an angle-of-attack indicator (airspeed indicator blocked out) as primary speed control. Pilot performance as compared to performance with the airspeed indicator as primary speed control was slightly improved. A series of 6° steep approaches was made in simulated certification landing tests with dry and wet runways at various water depths. Runway friction, stopping, and landing distances were measured, and stopping distance ratios are shown. Maximum vertical touchdown velocities on steep approaches were also evaluated.

NA-73-104

MODELING AIR TRAFFIC PERFORMANCE MEASURES, VOLUME I: MESSAGE ELEMENT ANALYSES AND DICTIONARIES

J. S. Hunter, D. E. Blumenfeld, and D. A. Hsu

Interim Report, July 1974 320p.

(RD-73-147, I) (AD 782 437)

This report contains analyses of voice communications between aircraft and controller, with the objective of describing the overall patterns of these transactions. In particular, the distributions of message element frequencies and transmission times are examined. Comparisons between ground-initiated and pilot-initiated transmissions show little differences in the distributions. However, there are considerable differences when the data are broken down into messages made during first, last and other communication transactions. Distributions of operational characteristics (i.e. request, acknowledgment, etc.) also differ between ground- and pilot-initiated transmissions. Detailed dictionaries of the different message combinations appearing as transmissions are given in the second part of the report.

NA-73-104

MODELING AIR TRAFFIC PERFORMANCE MEASURES VOLUME II: INITIAL DATA ANALYSES AND SIMULATIONS

J. S. Hunter, D. E. Blumenfeld, and D. A. Hsu

Interim Report, July 1974 483 P.

(AD-73-147, II) (AD 782 739)

This report examines the statistical characteristics of voice communications data recorded over a busy two-hour period covering the 101 sectors of the New York ARTCC. This study is the first stage of a larger effort to construct a simulation model descriptive of the aircraft flow and communication performance surrounding a major airport. The approach has been to get the data to speak for themselves prior to any extensive effort to construct a large simulation model. The structure of communications transactions, transmissions, and message elements are analyzed, and the frequencies and durations of these components are



described by statistical models. Channel utilization is defined and empirical equations identifying sector structure variables of greatest influence are constructed and compared. Models for aircraft arrivals, departures, and time in sector are postulated. A preliminary simulation model for a single sector is described and exercised. Aircraft flow transition matrices, and networks association sectors with different functions, are identified. The beginnings of an airport simulation model are sketched. Finally, the dynamics of aircraft flow are modeled, fitted and submitted to various diagnostics checks.

NA-73-105

DISTANCE MEASURING EQUIPMENT TRAFFIC-LOADING CAPACITY INVESTIGATION

Harold Postel

Final, June 1974 99 P.

(RD-74-93) (AD 780 959)

The report covers findings of the distance measuring equipment (DME) traffic counts from selected facilities. The data is to provide a basis for estimation present and future DME traffic-handling capabilities. DME traffic counts were conducted at the following facilities: Miami, Florida; Atlanta, Georgia; Robbinsville, New Jersey; Gardner, Massachusetts; Long Beach, California; Los Angeles, California; Oakland, California; Nottingham, Maryland; and Modena, Pennsylvania. The Miami, Florida, VORTAC showed the greatest amount of DME traffic; approaching 56 percent of capacity during peak periods.

NA-73-107

REDUCTION OF VOLTAGE STANDING WAVE RATIO ON DOPPLER VERY HIGH FREQUENCY OMNIRANGE

Wayne E. Bell

Final, April 1974 11 P.

(RD-74-45) (AD 777 624)

This report describes an investigation into the cause of increased voltage standing wave ratio (VSWR) in Doppler very high frequency omnirange (VOR) carrier, sideband, and goniometer feedlines. The results of the investigation show that the VSWR tolerances listed in paragraph 227b(3) of Handbook 6790.4, can be achieved when (1) a 54.7° modulation bridge is used, (2) when making goniometer feedline VSWR measurements and the carrier feedline is terminated in a dummy load, and (3) when a stub positioner section is used with the L14 stub in the sideband feedline.

NA-73-109

NATIONAL AIRSPACE SYSTEM ENROUTE STAGE A SYSTEM ENGINEERING AND ANALYSIS, INVESTIGATION OF SYSTEM PROBLEMS, CAPACITY TESTING

Harry T. Morgan, Jr.

Final, April 1974 28 P.

(RD-74-51) (AD 778 479)

A series of special engineering tests was designed to determine what, if any, capacity limitations would occur when NAS 3dl was operated under steadily increasing traffic load. The tests were performed at the National Aviation Facility Experimental Center (NAFEC) employing the Digital Simulation Facility and the System Support Facility. Both the Display Channel Complex and the Computer Display Channel modes of operation were investigated. NAS 3dl successfully met capacity test criteria. This report describes these tests and the results obtained.

NA-73-110

THE FEASIBILITY OF DETECTING A BURNER-CAN BURN-THROUGH BY MEANS OF CO, CO<sub>2</sub>, PRESSURE, AND AIR TEMPERATURE LEVELS IN A JET ENGINE NACELLE

Richard Hill

Final, March 1974 25 P.

(RD-74-18) (AD 775 304)

Full-scale tests simulating engine combustion section thermal failure (burn-through) were conducted using a cowled J-57 engine to determine the feasibility of detecting a burn-through by monitoring the carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), a pressure level, or air temperature in the nacelle before, during, and after engine case rupture. Results of the tests indicated that CO, CO<sub>2</sub>, pressure, and air temperature in the nacelle cannot be relied upon for early detection of a burn-through. Test results also indicated that containment of a burn-through flame in the nacelle creates extremely high temperatures in the nacelle and can cause extensive structural damage.

NA-73-113

TEST AND EVALUATION OF A FEASIBILITY MODEL FOR ILS PERFORMANCE ASSURANCE ON FINAL APPROACH, TOUCHDOWN, AND ROLLOUT

Morris Ritter

Final, April 1974 62 P.

(RD-74-66) (AD 778 146)

An evaluation was conducted at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, to determine the feasibility of a ground monitoring system to accurately detect the path of selected aircraft when on final approach and to eventually use this tracking information to provide a data base for statistical analysis of the Instrument Landing System (ILS) glide slope and localizer performance. The interferometer system (test system) was evaluated by comparing conic angles generated by the interferometer to conic angles generated by the NAFEC phototheodolites during flight approaches (time-paired). Analysis of the data revealed that the interferometer system was not adequate to effectively perform as an ILS performance assurance monitor.

NA-73-155

SMOKE EMISSION FROM BURNING CABIN MATERIALS AND THE EFFECT ON VISIBILITY IN  
WIDE-BODIED JET TRANSPORTS

Edward L. Lopez

Final Report, March 1974 127 P.

(RD-73-127) (AD 776 963)

A study was made of the smoke emission of cabin materials in ten major categories of aircraft interior construction under various burning conditions. Two materials in each category tested represented high to low smoke emission values. A wide-bodied cabin mockup, 2774 cubic feet in volume was used to establish correlation with the 18 cubic foot NBS-type smoke chamber. Additionally, selected materials were tested in the wide-bodied mockup to relate human visual acuity to optical density with and without ventilation flow through the mockup. Results of the study indicate that fair to good correlation exists between the NBS-type smoke chamber and a cabin mockup for various sizes of materials tested in the mockup. Results of visibility studies indicate the relationship of optical density to human visual acuity with and without irritating gases and with and without ventilation flow rate through a wide-bodied cabin mockup.

NA-74-1

DATA LINK SHORT-MESSAGE COCKPIT DISPLAY TEST

Donald Larson

Final, December 1974 125 P.

(AD A005 988)

Evaluation was made of four pilot/cockpit displays for air traffic control messages. The four displays were: (1) gas discharge, (2) light-emitting diodes, (3) fiber optics, and (4) cathode-ray tube displays. Data obtained were in the form of questionnaires and measured controller response time to the messages. The results will be used to determine the optimum display for crew environment tests. It was found that, through training and practice, pilot crews can readily set up cockpit procedures and operate in an ATC data link display communications environment.

This report documents a series of tests on cockpit input/output devices performed in a GAT-II cockpit simulator at the National Aviation Facilities Experimental Center during November 1973. These tests were in support of the Systems Research and Development Service Air-Ground Data Link Development Subprogram. Additional human factors analysis performed by the Transportation System Center based on these tests is documented in the following report: Hilborn, Edwin H., "Human Factors Experiments for Data Link: Interim Report No. 4," Report No. FAA-RD-74-81.

NA-74-2

LONG BEACH, CALIFORNIA, THREE-DIMENSIONAL, VISUAL FLIGHT RULES, GENERAL  
AVIATION AIRPORT STUDY

W. Robert McCosker and Leo J. Mulry

Final, April 1974 50 P.

(RD-74-40) (AD 778 924)

During a 3-hour survey period on July 21, 1973, 235 aircraft of 39 mixed types made 514 point-to-point and local airport flights to or from the Long Beach Airport, California. These flights represented a normal general aviation flight day for this location during the preferred flying season of the year, generally conceded to be July, August, and September. Survey data presented in this report are one facet of the Federal Aviation Administration Research and Development effort to obtain comprehensive, real-life, three-dimensional traffic samples of flight activity for the construction of air traffic models designed to demonstrate present activities and densities and to serve as a data base for future aircraft movement projections and air traffic systems and hardware development.

RELATED DOCUMENT:

"Statistical Summary of the 1983 Long Beach Standard Traffic Model,"  
FAA-RD-74-41.

NA-74-3

INVESTIGATION OF SHIELDING METHODS AND MATERIALS FOR REDUCTION OF RADIOFREQUENCY INTERFERENCE TO BACKUP EMERGENCY COMMUNICATION EQUIPMENT

George C. Apostolakis and Arthur R. Moss

Interim, April 1974 38 P.

(RD-74-61) (AD 779 293)

Backup emergency communication (BUEC) equipment operation in the field has been reported to be impaired by radiofrequency interference (RFI). This RFI enters the BUEC transceiver via its antenna as well as directly through imperfections in the internal shielding of the transceiver itself. Methods of reducing the effect of this RFI by shielding of the antenna and the transceiver itself were studied at the Elwood, New Jersey, Long-Range Radar Site. It was found that the radome catwalk deck itself was an effective shield against both ultrahigh frequency (UHF) and very high frequency (VHF) RFI, and that moving the antenna radially inward from the protective rail of the catwalk provided effective shielding. Additionally, it was found that UHF RFI generated by the common digitizer (CD) was completely eliminated by a 6X6-foot copper mesh screen interposed between the BUEC antenna and the CD, however, this means did not provide complete shielding for VHF interference. Finally, direct RFI leakage into the transceiver appears to be through the front end of the transceiver.

NA-74-4

DAIR SYSTEM RADAR TARGET RELATIONSHIPS

Allen C. Busch and Paul W. Bradbury

Final, October 1974 32 P.

(RD-74-155) (AD A001 037)

To assist the FAA in evaluation of the DAIR system against other ARTS II candidates, measurement data were collected in 1969 on a prototype DAIR built by Whittaker Corporation, and an analysis was made of the relative accuracy of the digitized radar target symbol position versus the primary radar target. Radar

track of one aircraft on radial courses was photographed as displayed in both primary and beacon radar modes, and also as processed through the DAIR system. Quantitative results were statistically analyzed to determine differences between primary radar position and displayed position, and to determine the distribution of the center of the displayed DAIR radar target position about the center of the primary radar target position. Results indicated that the DAIR system tended to display the DAIR center mark at a closer range and at a smaller azimuth angle than the center of the primary radar signal. The altitude of the aircraft did not appear to have any consistent effect on these measurements; however, the range of the aircraft did indicate a tendency to affect the measurements.

NA-74-5

INSET AND POLE-MOUNTED APPROACH LIGHTING SYSTEM SEQUENCE FLASHERS

E. Leon Reamer

Final, April 1974 50 P.

(RD-74-58) (AD 777 816)

The subject report was to determine the suitability of two types of sequence flashers, pole-mounted and inset, to operate in an approach zone incorporating either inset lighting or above ground lighting. The work involved: (1) laboratory photometric measurements; and (2) analysis of pilot's response to test flying the light systems. The results of the tests indicate that with minor modification the units may be used in the field.

NA-74-6

COMPARISON OF EXHAUST EMISSIONS OF A LOW-TIME JT8D-11 ENGINE: HIGH-SMOKE VERSUS LOW-SMOKE COMBUSTION CHAMBER CONFIGURATIONS

Stephen L. Imbrogno and Thomas Rust, Jr.

Final, April 1974 29 P.

(RD-74-87) (AD 780 803)

Engine-core exhaust emissions were measured on a low-time JT8D-11 engine in both high-smoke and low-smoke configurations. Changing from the high-smoke to the low-smoke configuration considerably reduced the visible smoke, 55 to 90 percent, as measured using the Society of Automotive Engineers (SAE) smoke number. Carbon monoxide was reduced by up to 40 percent. Total unburned hydrocarbons were reduced by 40 percent at idle power, while the production of oxides of nitrogen was increased by 60 percent at the high power setting. These percentages are absolute with no consideration for time in mode, according to the Environmental Protection Agency (EPA) landing/takeoff cycle.

NA-74-7

JET ENGINE BURN-THROUGH FLAME CHARACTERISTICS

Richard Hill

Final, July 1974 35 P.

(RD-74-19) (RD 781 795)

Tests were run to determine the effect of the angle and radius of curvature of a fire wall, with respect to a burn-through flame, on burn-through time. No difference was noted in burn-through time for angles of zero-, 10-, or 20-degrees. A slight increase was noted at 30 degrees, and at 40 degrees no burn-through occurred. No great difference in burn-through time was noted with a change in the curvature of the firewall. Centerline flatplate impingement pressures and temperatures were measured and graphed for burn-throughs having pressure ratios of 11:1, 9:1, 6:1, and 4:1, and hole sizes of 1, 1.5, and 2 inches. The exit velocity, density, and mass-flow rate were also calculated for those flames. The radial flatplate impingement profile was mapped for an 11:1 pressure ratio flame from a 1.5-inch hole. Flame characteristics of 16:1, 20:1, and 25:1 pressure ratio burn-throughs were estimated. Three appendixes are included in this report: (1) The Design of a Standard Burn-Through Simulator; (2) Determination of a Standard Burn-Through Hole Size; and (3) A Summary of Burn-Through Work at NAFEC From January 1, 1972, to December 31, 1973, including Results and Conclusions.

NA-74-8

MEASUREMENT AND ANALYSES OF ASR-4 SYSTEM ERROR PART III: SUMMARY

Allen C. Busch and Paul W. Bradbury

Final, December 1974 73 P.

(RD-73-62, III) (AD A004 309)

The positional accuracy of aircraft radar targets displayed in an air traffic control airport surveillance radar system (ASR-4) was measured as one of the inputs essential for determining aircraft separation standards. Using radar track input from Atlantic City (New Jersey) ASR-4, radar targets of two test aircraft executing flight patterns of varying relative spacing were photographed as displayed in both beacon and primary radar modes on scan-converted and plan position indicator (PPI) displays. The displayed positions were related to simultaneous precision track from single-target instrumentation radars, and a data bank was developed of error measures for range, azimuth, and separation. The extensive analysis program employed a "least squares" analysis of variance. The data clearly demonstrated the strong interdependency of the individual components that contribute to radar system separation error. Further, it was noted that the tails of the distribution of the radar separation error response measure were not normally distributed. In this report, Part III: Summary, data has been pooled for all like system response measures from two extensive data sets previously reported out as Phase I Data and Phase II Data (reflecting a difference in measurement instrumentation) in the associated report, Part II: Analyses, and an analysis of variance was then performed for the pooled expressions. In general, the pooled data shows a tendency to be more homogeneous and less subject to extraneous effects.

NA-74-9

TEST AND EVALUATION OF ATCRBS ELECTRONIC SCAN ANTENNA (PREPARATORY TEST)

Anthony D. Bradley

Interim, November 1974 62 P.

(RD-74-176) (AD A002 417)

The air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) as designed and built consists of 56 array modules placed on a platform (ring) constructed around the top of an airport surveillance radar tower. A shelter beneath the tower provides an enclosure for the control and radio-frequency distribution system of the ESA.

This interim report covers the preparatory testing to determine the readiness of the terminal radar/beacon test facility (TR/BTF) at the National Aviation Facilities Experimental Center to accept the ESA and provides a data base for comparison during the test program. In addition, the installation phase of the test and evaluation of the ATCRBS ESA is discussed in the report.

It was concluded that the data obtained during the test program was satisfactory and can be used as a basis for data comparison before and after installation of ESA at the TR/BTF. In addition the TR/BTF accepted the installation of the ATCRBS ESA with a minimum of physical adjustments. It also presented an environment suitable for testing which included ATCRBS vertical lobing and reflection problems.

NA-74-10

TEST AND EVALUATION OF THE PASSIVE FEEDHORN FOR THE AIR ROUTE SURVEILLANCE RADAR (ARSR-2)

Clifford Chapman

Final, September 1974

(RD-74-138) (AD 786 704)

A modified dual feedhorn antenna assembly for the air route surveillance radar (ARSR-2) was evaluated on a comparison basis with the normal feedhorn in attaining optimum radar coverage. Data indicated that ground clutter at close-in radar ranges was significantly reduced by use of a high-angle antenna beam (passive feedhorn) resulting in improvement in signal-to-clutter response at these ranges. Installation of the dual feedhorn antenna assembly as a field modification is considered feasible.

NA-74-11

THE 1973 LOS ANGELES AIR ROUTE TRAFFIC CONTROL CENTER'S AIR TRAFFIC MODEL

Francis M. Willett, Jr.

Final, June 1974 111 P.

(RD-74-42) (AD 781 387)

The purpose of the traffic sample model was to develop a standard to test future air traffic systems and equipment. A model was constructed of a three-dimensional aircraft movement operating in the Los Angeles Air Route Traffic Control Center's (ARTCC) area. The model contained Instrument Flight Rule flight operational data which occurred on March 14, 1973, under the control of the Los Angeles ARTCC during a 3-hour period. An air traffic model was developed consisting of 619 operations generated by 512 aircraft flights. This model is representative of the operations of a high-density domestic center. Also included are data analyses of the operation of airports and aircraft in the model. Report Number FAA-RD-74-43 refers to a related document.

NA-74-12

TEST AND EVALUATION OF PASSIVE HORN ANTENNA FOR THE AIRPORT SURVEILLANCE  
RADAR-5

Dominick L. Offi

Final, July 1974 48 P.

(RD-74-113) (AD 787 748)

A passive horn modification kit was developed by the Raytheon Company for the National Aviation Facilities Experimental Center, Airport Surveillance Radar-5 test bed. The modified system was evaluated to determine the extent of performance improvements realized and to assess its applicability to all airport surveillance radars.

System tests indicated the modification had no deleterious effect on the normal, low-beam coverage, and provided an improvement in signal-to-clutter ratio when small aircraft were competing with various forms of clutter.

It was recommended that a passive horn modification providing dual-beam capability for all airport surveillance radars be considered for field implementation.

NA-74-13

INVESTIGATION OF RADIOFREQUENCY INTERFERENCE TO THE BACKUP EMERGENCY  
COMMUNICATION EQUIPMENT AT THE ELWOOD, NEW JERSEY, LONG-RANGE RADAR SITE

George Apostolakis and Arthur Moss

Final, July 1974 37 P.

(RD-74-115) (AD 783 633)

Backup emergency communication (BUEC) equipment in the field has been reported impaired by radiofrequency interference (RFI). This problem was investigated by the National Aviation Facilities Experimental Center at the long-range radar site located at Elwood, New Jersey. The investigation showed that the two major sources of RFI were the common digitizer (CD) (with its doors open) and the radar. The RFI from the radar was concentrated into solid, broad-frequency bands 1 to 4 megahertz (MHz) wide, and was evident on the ground level only. The RFI from the CD occurred at discrete frequencies, and was evident on the equipment building roof and radar tower catwalk, as well as on the ground level. Consistently strong RFI was noted at seven very high frequencies (VHF), ranging from 121.575 to 134.5 MHz, and at 11 ultrahigh frequencies (UHF) ranging from 299.40 to 305.55 MHz. RFI at UHF frequencies on the catwalk rail was found to be eliminated by suspending a 6X6-foot copper mesh screen on the catwalk deck underneath and outward from the BUEC antenna. Finally, it was found that moving the BUEC antenna radially inward from the protective rail and mounting it above the catwalk deck provided effective shielding at both VHF and UHF.



NA-74-14

TEST AND EVALUATION OF A REMOTE CONTROL AND RADIOFREQUENCY REPEATER SYSTEM FOR  
TELEVISED RADAR DISPLAY APPLICATIONS

James G. Dong

Final, September 1974 38 P.

(RD-74-40) (AD 786 273)

Evaluation was accomplished on engineering models of a remote control system (TCS) for a BRITE-2 televised display and a radiofrequency (RF) repeater operating at 14.87 and 15.07 GHz. Major portions of the laboratory tests were achieved during the factory acceptance tests. Testing at the National Aviation Facilities Experimental Center was directed toward establishing a system configuration appropriate for a satellite airport. The RCS operational capability utilizing a C1-conditioned voice-grade line was assured. The RF repeater was compatible with an existing microwave link which permitted experiments with mixed radar video and alphanumeric data inputs into the RF system. With the addition of the new equipments, system versatility was increased.

NA-74-16

PRELIMINARY TWO-DIMENSIONAL AREA NAVIGATION TERMINAL SIMULATION

John Maurer, Paul J. O'Brien, and William Crimbring

Final, February 1975 95 P.

(RD-74-209) (AD A006 263)

A dynamic simulation, using the digital simulation facility at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, was conducted to determine the effect on the air traffic control (ATC) system and the system users resulting from the use of area navigation (RNAV) in a high-density terminal area. The John F. Kennedy Airport airspace, with RNAV routes designed by Champlain Technology, Inc., and modified by the NAFEC simulation team, was used as the test bed for study. The simulation study analyzed selected controller workload and system performance measures for two route configurations representing two time frames and various percentage mixes of RNAV and non-RNAV operations, referred to in this report as participation levels. Results indicated that controllers could use RNAV maneuvers in the control of traffic in lieu of radar vector techniques and that controller workload decreased as the RNAV participation level increased. Controller acceptance of RNAV principles and techniques in terminal ATC increased as familiarity and experience with the various RNAV functions were gained. Subjective results pointed out that RNAV is an effective tool within the terminal air traffic system, adequate training and a thorough familiarization with RNAV procedures, capabilities, and limitations would be a requirement for both controllers and pilots. In addition, avionics equipments would be required to be able to perform standardized "parallel offset" and "direct-to-waypoint" maneuvers and, of necessity, would require simplicity in use in order that pilots can respond to ATC RNAV instructions as effectively and promptly as to radar vectors.

NA-74-17

EVALUATION OF TECHNIQUES USED IN THE BUTLER TERMINAL AREA MODEL 1020 DISTANCE MEASURING EQUIPMENT

Robert H. Erikson

Final, February 1975 38 P.

(RD-74-208) (AD A006 265)

This report covers the evaluation of some techniques used in the low-power (terminal area) Butler 1020 distance measuring equipment (DME). The equipment was delivered to the National Aviation Facilities Experimental Center where laboratory tests were conducted. Laboratory tests dealt with the evaluation of the traffic-handling capability, echo-suppression circuitry, and the effects of first-pulse and second-pulse timing techniques. It was concluded that (1) with interrogation-pulse spacings of other than exactly 12  $\mu$ s, first-pulse timing is effective in maintaining the reply delay between the first pulse of the interrogation to the first or second pulse of the reply constant, and (2) the echo-suppression circuits were effective in reducing the number of replies to false interrogations.

NA-74-18

AUTOMOTIVE LATERAL-IMPACT COLLISION TESTS PHASE I

Hugo Scheuerman and Roger Young

Final, February 1975 184 P.

(HS-801 360) (PB 240 121)

A series of lateral-impact tests were conducted to determine the worst impact angle with respect to automobile intrusion using the Society of Automotive Engineers moving-barrier. Automobiles were impacted at 20 mi/h, and the impact angle was varied from 50° to 80°. The maximum vehicle intrusion occurred in the tests with a 60° impact angle.

NA-74-19

EVALUATION OF A HIGH-CAPACITY, FIREFIGHTING, FOAM-DISPENSING SYSTEM

George B. Geyer, Lawrence M Neri and Charles H. Urban

Final, January 1975 46 P.

(RD-74-204) (AD A006 264)

A series of six tests was conducted using a single barrel mechanical foam nozzle discharging 1,800 gallons of foam solution per minute (English/metric conversion factors are given in appendix A). Three experiments were conducted with protein foam and three using aqueous-firm-forming-foam (AFFF). The tests were designed to dispense foam solution at a fixed rate in simulated full-scale fire-modeling experiments in which the fire area was smaller than the total area of foam application, thereby conserving fuel and reducing atmospheric contamination. The time required to foam-cover concentric circular diked areas of 12,000, 18,000, and 36,000 square feet containing a three-dimensional fire in a 2,827 square foot fire-pool was determined. The foam quality and ground patterns produced by each agent were determined for solution rates of 840 and 1,800 gallons per minute.

NA-74-20

PRELIMINARY TEST AND EVALUATION OF THE INTERMITTENT POSITIVE CONTROL/AIR TRAFFIC CONTROL SYSTEM INTERFACE WITH THE NAS ENROUTE SYSTEM

Frederick Ranger and John Goodwin

Interim, January 1975 22 P.

(RD-74-163)

This report describes the preliminary evaluation of the intermittent positive control (IPC) concept when interfaced with the air traffic control system. Tests were conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in a dynamic interactive controller environment simulating a low-altitude enroute airspace using digital beacon target data. Tests were designed for a preliminary evaluation of the IPC-controller display interface with respect to the timeliness and adequacy of the IPC alert and command functions. Tests were conducted in two modes of operation: a controller "hands-off" mode in which only the IPC algorithm was allowed to resolve a hazardous situation by issuing appropriate safety maneuver commands, and a "hands-on" mode in which the controller would take action to resolve a situation without waiting for the algorithm to issue a command. Results indicate that the information displayed to the controller could be immediately and correctly interpreted. (When the information was intended for voice delivery to the pilot, the concept was less than completely adequate due to the late display of information in terms of time remaining for decisive action.) In addition, contradictory commands displayed to the controller on successive computations of the algorithm for the same aircraft resulted in a less than favorable controller response to the IPC concept as tested. Data analysis indicated that, to bring the system to a satisfactory level of effectiveness with respect to timeliness and adequacy of the alert and command functions improvements in the algorithm logic are necessary.

NA-74-21, I

THE CONTROLLER/COMPUTER INTERFACE WITH AN AIR-GROUND DATA LINK VOLUME I

S. Rossiter (NAFEC), R. Wiseman (TSC), M. Connelly (MIT/ESL), T. Morgan (CSC)

Final, September 1975 13 P.

(RD-75-133, I) (AD A017 086)

A dynamic simulation study was conducted to determine the display techniques and operating procedures that best enable an air traffic controller to work in a mixed voice/digital communications environment. The study focused on the benefits that might accrue to ground-based automatic control through further automation of the controller's communication tasks. The simulation was performed at the National Aviation Facilities Experimental Center as a joint effort with the Department of Transportation, Transportation Systems Center. A simplified version of the ARTS III Metering and Spacing System was used to assess the controller's communication task when automatically generated control commands were transmitted to voice link or to data link-equipped aircraft in terminal approach traffic. Subject to follow-on testing of a more operational nature, it was concluded that a data link channel efficiently augments the voice channel, the

value increasing as the percentage of data link aircraft increases. System test measures and questionnaire results show that further efficiencies can be obtained through the use of computer-generated speech, one-at-a-time display of commands moving with the aircraft target symbol, and by the automatic transmission of commands on both the voice and data link channels. The automatic command transmission eliminates the controller's tasks of approving commands, placing more emphasis on traffic situation monitoring. With a careful optimization of display formats and operating procedures, the controllers' acceptance of automation features will improve while they are still provided with safe traffic management and recovery techniques during system failures.

NA-74-21, II

THE CONTROLLER/COMPUTER INTERFACE WITH AN AIR-GROUND DATA LINK (VOLUME II)  
S. Rossiter (NAFEC), R. Wiseman (TSC), M. Connelly (ESL/MIT) and T. Morgan (CSC)  
Final, September 1975 250 P.  
(RD-75-133, II) (AD A017 369)

A dynamic simulation study was conducted to determine the display techniques and operating procedures that best enable an air traffic controller to work in a mixed voice/digital communications environment. The study focused on the benefits that might accrue to ground-based automatic control through further automation of the controller's communication tasks. The simulation was performed at the National Aviation Facilities Experimental Center as a joint effort with the Department of Transportation, Transportation Systems Center. A simplified version of the ARTS III Metering and Spacing system was used to assess the controller's communication task when automatically generated control commands were transmitted to voice link or to data link-equipped aircraft in terminal approach traffic. Subject to follow-on testing of a more operational nature, it was concluded that data link channel efficiently augments the voice channel, the value increasing as the percentage of data link aircraft increases. System test measures and questionnaire results show that further efficiencies can be obtained through the use of computer-generated speech, one-at-a-time display of commands moving with the aircraft target symbol, and by the automatic transmission of commands on both the voice and data link channels. The automatic command transmission eliminates the controller's tasks of approving commands, placing more emphasis on traffic situation monitoring. With a careful optimization of display formats and operating procedures, the controllers' acceptance of automation features will improve while they are still provided with safe traffic management and recovery techniques during system failures. Volume I of this study is a Summary Report.

NA-74-22

TEST OF GLIDE SLOPE GUIDANCE WITH AND WITHOUT SIMPLIFIED ABBREVIATED VISUAL  
APPROACH SLOPE INDICATOR  
Guy S. Brown and Richard L. Sulzer  
Interim, October 1974 30 P.  
(RD-74-139) (AD 787 304)

In a flight test at a small airport, rectangular aiming-point markings with and without the additional use of a low-cost version of the red/white simplified abbreviated visual approach slope indicator (SAVASI) served as daytime approach guidance aids. Results showed that approaches made with the SAVASI were less variable in measured approach slope, and approaches made in the last half-mile before landing were nearer the 4° SAVASI glidepath angle. On average, approaches made either with or without the SAVASI were steeper than 4°, and tracking of itinerant aircraft not informed of the testing confirmed that the usual approach for small aircraft at this runway was in the 5° to 6° range. This indicates that future installations of SAVASI or related guidance aids should be made after measuring the normal practice at a given airport. Test pilot opinion was that the SAVASI was easy to use and provided good guidance in the vertical plane and that the rectangular aiming-point markings were beneficial.

NA-74-23

EVALUATION OF AN EXPERIMENTAL ELEVATED HIGH-INTENSITY RUNWAY EDGE LIGHT

E. Leon Reamer

Interim, September 1974 65 P.

(RD-74-128) (AD 785 016)

The subject effort was to determine the suitability of a newly designed elevated runway edge light to function in category I and category II operations when a high-intensity runway-light environment is prevalent. The work involved laboratory photometric measurements and analysis of pilot response after test flying the newly designed runway lighting system. The results of the tests indicated that the new design concept is appropriate for use under the conditions tested.

NA-74-24

SYSTEM FAILURE AND RECOVERY TESTS NAS ENROUTE STAGE A MODEL 3d2

Donald A. Fisher and Lane G. Hinkley

Final, December 1974 20 P.

(RD-74-181) (AD A003 121)

A series of tests of the National Airspace System Enroute Stage A Model 3d2 System was conducted at the National Aviation Facilities Experimental Center in a system environment in order to determine system behavior under conditions of hardware element failures and in order to determine the impact of the failures upon air traffic control operations. This report describes the results of these tests, but does not include later improvements or additions to the system which may have been included as a result of these tests or other similar activities.

NA-74-25

TECHNICAL EVALUATION OF WEATHER CLUTTER FEASIBILITY MODEL

Ronald S. Bassford

Final, September 1974 70 P.

(RD-74-137) (AD 787 607)

An ASR-5 weather clutter feasibility model was developed and evaluated to determine its capability to provide air traffic controllers with a weather display (clutter free) of air traffic and a contour depiction of weather detected by radar. The technical tests included the determination of technical characteristics of each of four modifications (narrow transmitter pulse width, noncoherent moving target indicator, dual frequency diversity, and logarithmic/fast time constant) which comprised the weather rejection portion of the system along with their capabilities to provide clutter rejection and target detection in weather. The four modifications were then tested in unison to determine the system's overall capability. The weather channel portion of the equipment was tested to determine its capability to provide weather clutter formatting in the form of isoamplitude contours. The results of the test demonstrated that the weather clutter feasibility model does not effectively perform the designed functions of weather clutter rejection and weather clutter contouring. Its capability to provide weather clutter contouring ranges from good, for high-level well defined weather cells, to poor, for low-level scattered cells. The equipment is not acceptable for use in the air traffic control system.

NA-74-26

DEVELOPMENT OF A STACKED FIVE-BAY VOR ANTENNA SYSTEM

Edward N. Lind

Final, June 1975 75 P.

(RD-75-9) (AD A013 917)

This final report describes an operational evaluation of a single bay and a stacked five-bay VOR antenna on a conventional VOR counterpoise at the National Aviation Facilities Experimental Center (NAFEC). The results of the evaluation show that the stacked antenna is unacceptable in its present form for use at a commissioned VOR station. Electrical problems are: (1) how can each antenna or all antennas be monitored, (2) detection of change in vertical pattern, and (3) excessive bearing error. There are unsolved physical problems such as: (1) method of repairs to an antenna or hybrid units located within the mast, (2) adjusting length of polarization rods, and (3) replacement of obstruction light.

NA-74-28

THE MEASUREMENT OF THE McDONNELL-DOUGLAS DC9 TRAILING VORTEX SYSTEM USING THE TOWER FLY-BY TECHNIQUE

Leo J. Garodz, David Lawrence, and Nelson Miller

Final, November 1974 99 P.

(RD-74-173) (AD A001 456)

The results are presented of a series of low-altitude (approximately 200 feet above ground level) flight tests performed at the National Aviation Facilities Experimental Center NAFEC), Atlantic City, New Jersey, in which the trailing vortices of the McDonnell-Douglas DC9 airplane were investigated, using a 140-foot instrumented tower. Flow visualization (colored smoke streams) was

employed and film records made. The airplane was tracked by the NAFEC photo-theodolite facility. Data presented consists of plots of vortex tangential velocity distribution, peak velocity as a function of time, airplane configuration and windspeed, vortex descent rates, and lateral transport rates. Principal findings were that: (1) Within the time period 30 - 100 seconds after vortex generation, the peak velocities within the vortices were bounded by the function  $V\theta = 396 \exp(-.0347t)$ , with a half-life of 20 seconds; (2) Vortex cores were uniformly small (1 - 2 feet) in both configurations tested (takeoff and landing), and little or no growth with time was found; (3) Vortex lateral transport velocities correlated well with the crosswind measured at 140 feet; and (4) The presence of a temperature inversion markedly retarded the vortex descent rates. The highest peak recorded tangential velocity was 120 - 130 feet per second, found to occur in both configurations tested.

NA-74-30

INVESTIGATION OF THE VORTEX WAKE CHARACTERISTICS OF JET TRANSPORTS DURING CLIMBOUT AND TURNING FLIGHT

Leo J. Garodz and Nelson J. Miller

Final, May 1975 118 P.

(AEQ-75-1) (AD A012 383)

The characteristics of the trailing vortices of several large propeller and jet transport aircraft have been investigated by the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. This investigation centered around jet transport vortex persistence and movement during noise abatement-type departure operations at the Los Angeles International Airport and how approaching aircraft could avoid these vortices, however, it is concluded that the results and conclusions would be applicable to similar operations at other airports. The study is primarily based upon full-scale flight tests of vortex characteristics and their effect on encountering aircraft, conducted by NAFEC, NASA, Boeing and the Royal Aircraft Establishment (RAE). Special flight tests for vortex investigations of the B727 during noise abatement climbouts, straightaway and turning flight, in takeoff and clean configuration are included. Vortex-generating aircraft included C5A, B747, B707, B727, DC7, CV880, and Lincoln; vortex probe aircraft included CB990, B737, Learjet 23, DC9, and Devon. A vortex avoidance zone was developed which has an active life of 2 minutes when below 5,000 feet above ground level and 2.6 minutes when higher than 5,000 feet above ground level.

NA-74-32

FLIGHT TESTS OF THE ROME AIR DEVELOPMENT CENTER TARGET ENHANCING LINEAR RELAY SYSTEM

Dominick Offi

Final, October 1974 27 P.

(RD-74-141) (AD 787 309)

An aircraft echo-area enhancement device, developed by the Stanford Research Institute for the USAF Rome Air Development Center, was flight tested at the

National Aviation Facilities Experimental Center. The device, known as a target enhancing linear relay system was installed aboard a Piper Cherokee 180 aircraft and tracked with the airport surveillance radar-5 test bed. The data was analyzed to determine the extent of improved target detection capability afforded by the enhancer. Flight tests indicated the system was an effective echo-area enhancer when the aircraft was at long ranges in a tail-on aspect, and that performance was affected by antenna shielding problems. It was recommended that development of similar systems be continued, with emphasis on solving possible radiofrequency interference, economic, and antenna problems.

NA-74-33

GRAPHIC STUDY OF A SELECTED SITE FOR A SECOND MAJOR AIRPORT IN THE ATLANTA, GEORGIA, TERMINAL AREA

John Maurer, W. Robert McCosker, and Francis Willett

Final, August 1974 33 P.

(RD-74-133) (AD 783 751)

This graphic simulation study of the Atlanta air traffic control terminal area was requested by the Southern Region to assist in developing a feasible plan for airspace use and air traffic control operations in the Atlanta metropolitan area, assuming the establishment of a second major airport. The second major airport was assumed to be located in the Paulding/Polk County area of Georgia, approximately 15 nautical miles west of Dobbins Air Force Base/Naval Air Station Atlanta, Marietta, Georgia. The study considered instrument operations to all instrument flight rule airports within the Atlanta terminal area. The primary runway configuration considered at the new airport was a northwest/southeast alignment of four parallel runways with two additional parallel north/south runways. The present major airport, William B. Hartsfield Atlanta International Airport, was considered to have four parallel east/west runways. Three other runway alignments for the new airport, a west/northwest and southwest were also studied.

The airspace utilization plan herein is an acceptable and feasible plan for the overall Atlanta Terminal Area Complex. This graphic study shows that the present Hartsfield International (Atlanta) Airport and the new proposed airport could operate simultaneously with little interaction; however, the placement of the proposed airport places impacts of varying degrees upon satellite airport operations.

NA-74-34

FLIGHT TEST OF DIAMOND AND OTHER PROPORTIONED RUNWAY PAINT MARKINGS FOR GLIDE SLOPE GUIDANCE

Guy S. Brown, Donald Eldredge, and Richard L. Sulzer

Final, November 1974 29 P.

(RD-74-166) (AD A001 038)

The glide slope guidance value of three patterns of specially proportioned paint markings on the approach end of a small airport runway was evaluated in a flight test which also included approaches using a red/white VASI and approaches using only normal visual cues. Both private and professional pilots were instructed



to approach on a glide slope such that the special paint markings, a diamond, an ellipse, or a pair of rectangles, appeared square or of equal dimensions in length and width. Results indicated that approaches made with the specially proportioned paint markings were similar to approaches made using only normal cues. While flight performance appeared to be unaffected by providing any of the special paint markings, approaches made using the red/white VASI were less variable. It is concluded that there is no evidence of improved performance supporting the previous claims that squareness judgments of runway paint markings provide significant aid in glide slope control. Additional tests conducted with diamond marks designed to provide a square image from 3° to 5° produced results indicating large errors in the undershoot direction.

NA-74-35

EVALUATION OF A VERY LOW FREQUENCY NAVIGATION SYSTEM

Richard Gober

Final, January 1975 109 P.

(RD-74-198) (AD A005 043)

The result of 32 flights using existing phase-stable very low frequency (VLF) communication stations for air navigation are presented. The Global Navigation System's (GNS-2QQ) VLF system was used to provide course deviation, distance-to-go, and groundspeed. Local flights, in range of the Extended Area Instrumentation Radar (EAIR) located at the National Aviation Facilities Experimental Center (NAFEC), were made in an Aerocommander aircraft. Flights in a Convair 880 were made to the West Coast, Bermuda, Caribbean, Arctic Circle, and across the North Atlantic to Europe and return. VOR and DME data were used for position reference on the flight to California. The LTN-51 inertial navigation system display was photographed at regular intervals for use as a reference on oceanic flights. The National Aeronautics and Space Administration (NASA) tracking radar at Bermuda was used for reference for flights in the vicinity of Bermuda.

Conclusions are: (1) VLF is an acceptable air navigation aid and exceeds the positioning and guidance features of Loran A. The weakest point is the availability of VLF ground stations, (2) VLF signal strength and quality on these flights were acceptable for air navigation, (3) VLF should be considered as a replacement for Loran A, and (4) an adequate VLF monitoring system is not available.

NA-74-37

THE MEASUREMENT OF THE BOEING 707 TRAILING VORTEX SYSTEM USING THE TOWER FLY-BY TECHNIQUE

Leo Garodz, David Lawrence and Nelson Miller

Final, March 1975 124 P.

(RD-75-15) (AD A008 384)

The results are presented for a series of low-altitude (160-240 feet above ground level) flight tests performed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, in which the trailing

vortices of the Boeing 707 airplane were investigated using a 140-foot tower instrumented with airspeed, velocity, direction, temperature, and humidity sensors. Flow visualization was employed and motion picture records made. The airplane was tracked by the NAFEC Phototheodolite Facility. The data presented consists of plots of vortex tangential velocity distribution, peak tangential velocity as a function of time, airplane configuration, windspeed, and airplane altitude in proximity to the tower, vortex descent rates, lateral transport velocities, and specimen time histories of the velocities measured by individual sensors. Principal findings were that (1) within the time scale of the experiment, the decay envelope of the peak velocity approximately conforms to the exponential equation  $V_{\theta\max} = 485e^{-.0198t}$ , with a half-life of 35 seconds and (2) that the peak velocity of a vortex and the vortex core diameter are strongly affected by airplane configuration. Clean configuration produced high velocities, up to 200 feet per second, while in neither of the flapped configurations tested (takeoff,  $\delta f = 14^\circ$  and landing,  $\delta f = 40^\circ$ ) was a peak velocity greater than 110 feet per second found.

NA-74-39

EVALUATION OF THE RADAR INTERFACE MODIFICATIONS FOR THE AIR ROUTE SURVEILLANCE RADAR

William C. Swanseen

Interim, January 1975 41 P.

(RD-74-193) (AD A005 042)

Radar interface modifications were installed at the Elwood, New Jersey, air route surveillance radar-2 (ARSR-2) site. These radar interface modifications included a log intermediate frequency strip, radiofrequency sensitivity time constant generator, video processor, and channel change unit. A series of technical tests were run at the Elwood site to obtain pertinent information on the performance of the radar interface modification. It was concluded that the moving target indicator performance of the video processor was inadequate. The log normal video proved to be a stable video.

NA-74-41

EVALUATION OF AN EXPERIMENTAL HIGH-INTENSITY, INSET RUNWAY EDGE LIGHT FIXTURE

E. Leon Reamer

Interim, November 1974 18 P.

(RD-74-171) (AD A002 416)

The subject evaluation performed was to determine the suitability of an inset edge light fixture for use with specification L-819 elevated runway edge lights. The effort involved the taking of laboratory photometric measurements only. The results of the testing showed that the light fixture is suitable for use under the conditions tested.

NA-74-42

INSTRUMENTATION FOR PROPELLER BLADE VIBRATION FLIGHT AND GROUND TESTING

Anthony J. Barile

Final, August 1975 78 P.

(RD-75-83) (AD A015 244)

The need for in-flight propeller stress measurements has been evident for the last three decades. This report documents the various instrumentation systems, methods, and techniques particularly suited to this purpose.

The stress measurement process, in general terms, is considered with a more detailed description of the various options available to transmit signals from the propeller to the airframe. The procedures with which the transmitted signals may be recorded, processed, and reduced to meaningful information are presented with an assessment of their relative merits.

An in-depth description of strain gage installation techniques is presented, depicting short- as well as long-term all-weather installations, heretofore uncommon in the state-of-the-art.

Further discussion is addressed to electronic data processing and a typical flight test profile.

NA-74-44

RESPONSES OF SMALL RIGID AIRCRAFT TO DISCRETE AND CONTINUOUS GUST ANALYSIS - PHASE I

John Petrakis, SRDS, and Nelson Miller, NAFEC

Final, December 1975 120 P.

(RD-74-160) (AD A020 103)

An evaluation is made of methods developed for estimating longitudinal and lateral rigid-body responses of airplanes to random atmospheric turbulence (reference 2). A computer program has evolved from this study which calculates general aviation aircraft stability derivatives from known geometric properties to be used as inputs to the calculation of aircraft response (also a developed part of the computer program). It was found that the two degrees-of-freedom analysis for aircraft of gross weight from 3,000 to 17,500 pounds. Also to produce an equivalent discrete load factor for the two degrees-of-freedom analysis, a higher spectral velocity value must be used compared to that of the single degree-of-freedom approach of reference 1.

NA-74-45

TEST AND EVALUATION OF WIRE-WOUND TACTICAL AIR NAVIGATION AID (TACAN) HEATED RADOMES WITH WEATHER SENSORS

Harold Postel

Interim, September 1975 66 P.

(RD-75-96) (AD A015 724)

This report covers preliminary field evaluation at the Newberg, Oregon, Very High Frequency Omni-range Tactical Air Navigation Aid (VORTAC) of an engineering model wire-wound Tactical Air (TACAN) radome and weather-sensors and the wire-wound radome was to determine the feasibility of the weather sensors and the wire-wound radome in preventing snow and/or ice buildup. Three TACAN system outages occurred under moderate weather conditions during the 3 months of testing because of snow or ice accumulation on the TACAN radome and monitor antenna faceplate. An apparent power reduction was realized over conventional internal radome heaters; however, more stringent ON/OFF controls should be built into the heater, and production wire-wound radomes should be tested under more severe weather conditions necessary to properly determine the systems effectiveness are not prevalent at this particular facility.

NA-74-46

EVALUATION OF DIGITAL ALTIMETER SETTING INDICATORS

Robert Frack, Ernest E. Schlatter and Jack Bernstein

Final, August 1975 55 P.

(RD-75-81) (AD A013 994)

Altimeter setting values disseminated to the pilot are currently obtained from nonelectronic (aneroid) dial and pointer indicators. Electronic systems with potential for continuous sensing of ambient atmospheric pressure and subsequent conversion to altimeter setting values and remoting to multiple digital displays were tested at the National Aviation Facilities Experimental Center (NAFEC), Federal Aviation Administration, Department of Transportation, Atlantic City, New Jersey.

Ten such systems were subjected to warmup, accuracy, temperature, line voltage, and stability tests. Results were compared with a Hass MS-3 micrometer standard barometer.

Data on the results obtained and the test procedures are presented. The report concludes that electronic sensing and display of altimeter setting values is feasible, but subject to practical and economic restraints. Daily checks and occasional corrections will still be required.

NA-74-50

CHANNEL-LOSS DETECTOR FOR LOW-TRAFFIC TELETYPE CIRCUITS

Charles Santora

Final, May 1975 30 P.

(RD-75-1) (AD A011 681)

This report describes a prototype device for application at international flight service stations to detect teletype channel loss by providing an idle signal in the absence of messages and activating alarms when continuity is disrupted or a failure occurs which disables teletypewriter communication. Two units, each comprised of send and receive channel-loss detectors and teletypewriter circuit

interfaces and associated alarms, were developed and evaluated at the National Aviation Facilities Experimental Center in accordance with Systems Research and Development Service, Washington, requirements and were found to perform satisfactorily. As a digital device, the channel-loss detector may lend itself to other communication applications as needed.

NA-74-51

EFFECTIVENESS OF A PILOT GROUND TRAINER AS A PART TASK INSTRUMENT FLIGHT RULES FLIGHT-CHECKING DEVICE STAGE I

Robert J. Ontiveros

Interim, September 1975 50 P.

(RD-75-36) (AD A015 722)

The first stage of a two-stage experiment was conducted at the National Aviation Facilities Experimental Center (NAFEC) to determine the effectiveness of a pilot ground trainer for training noninstrument-rated pilots in instrument approaches and related instrument flight procedures. Ten private pilots were trained to perform very high frequency omnirange station (VOR), automatic direction finder (ADF), and instrument landing system (ILS) approaches. The pilot ground trainer represented a single-engine general aviation aircraft. The subjects' flight performance capability, achieved through ground trainer instruction, was evaluated by a flight check in an instrument-equipped Cessna 172. The results of this first stage of investigation indicate a positive transfer of training between observed pilot performance in the ground trainer and observed pilot performance in the aircraft for performing instrument flight approaches. The report provides information about trainer equipment and capabilities which contributed to the positive transfer. Procedural maneuver situations which resulted in minimal training transfer are discussed in terms of desirable ground trainer capabilities which could enhance the effectiveness of the pilot ground trainer for performing instrument flight approaches. With the stage I confirmation of pilot ground trainer effectiveness in an instrument training situation, a planned second stage of experimentation will determine if a ground trainer can be used effectively as a flight-checking device for pilots to demonstrate their ability to perform instrument flight test in an aircraft. A final report will be issued.

NA-74-53

RELIABILITY ANALYSIS OF THE SYSTEM MAINTENANCE MONITOR CONSOLE

Arthur R. Moss

Final, March 1975 97 P.

(RD-75-3) (AD A008 383)

The specification for the system maintenance monitor console (SMMC) calls for a minimum mean uptime (MUT) of 5,000 hours and a maximum mean downtime (MDT) of 1 hour for each SMMC module type. Formal MUT and MDT tests were performed in accordance with approved test plans. All module types passed the tests. An independent MUT analysis covering 3.75 equipment years of observation showed, with an 80-percent degree of confidence, that the true MUT's of all module types

except the 9020E-1 are greater than 9,000 hours. The corresponding MUT for the 9020E-1 may be as low as 4,500 hours. A total of 18 hard failures occurred over this 3.75-equipment-year period. Six of these involved blower motor failures in the power supplies.

A major cause of concern has been the high replacement rate and limited availability of the type 247 subminiature lamps used in the projection readout indicators (PRI's). Detailed replacement studies of these lamp failures brought out that an average of two lamps per day per SMMC failed. Comparative life tests were performed between the type 247 and three alternative type lamps, types 6180, 714, and 685. Types 714 and 685 showed significantly greater mean lives but lower luminosities than the 247. Human factors studies are being planned to determine the suitability of using lamps of lower luminosity.

NA-74-54

COLOR DISPLAY EVALUATION FOR AIR TRAFFIC CONTROL

Donald W. Connolly, Gerard Spanier, and Florence Champion

Final, May 1975 50 P.

(RD-75-39) (AD A010 779)

Three experiments and a survey-analysis of the state of the art were performed for the purpose of assessing the operational utility potential and the technical feasibility of penetration phosphor cathode-ray tube (CRT) displays in air traffic control applications. The experiments, designed to test the usefulness of color as an aid to air traffic information presentation, involved collection of data on several hundred responses from each of 25 to 30 subject-observers. Experiment I found that each of four colors could be identified with 97-to 99-percent accuracy. Experiment II demonstrated that use of color where display symbology overlaps (as target data blocks commonly will) can increase accuracy of interpretation by a factor of three or more over monochromatic display. Experiment III determined that use of color to augment or reinforce altitude information or future route-of-flight information did not improve controller performance in the prediction of separation rule violations. Use of color as the sole source of essential information (instead of some other means of presentation) was not tested. The suggestion is made that such applications should be tested in order to complete the operational applications picture. The engineering evaluation concluded that large (i.e., 22-inch) penetration phosphor screens are not readily available in production quantity. Similar source problems exist for the requisite CRT bottles, and high-voltage switching hardware. Linearity, brightness, resolution, and tube life expectancy do not approach those common for monochrome CRT's and are not likely to do so. Other techniques (high-resolution shadow mask, multigun penetrators) may have potential, but would require development.

NA-74-55

MEASUREMENT & ANALYSES OF ASR-4 SYSTEM ERROR, PART I: OVERVIEW

Allen C. Busch and Paul Bradbury

Final, November 1974 22 P.

(RD-73-62-I) (AD A002 748)

The positional accuracy of aircraft radar targets as displayed in an air traffic control airport surveillance radar system (ASR-4) was sought as one of the inputs essential for determining aircraft separation standards. Using radar track input from the Atlantic City, New Jersey, ASR-4, the radar targets of two test aircraft executing flight patterns of varying relative spacing were photographed as displayed in both beacon and primary radar modes on scan-converted and PPI displays. The displayed positions were related to simultaneous precision track from single-target instrumentation radars (FAIR and TAIR) to derive error measures for range, azimuth, and separation. The extensive analysis program employed a "least-squares" analysis of variance. The data clearly demonstrated the strong interdependency of the individual components that contribute to radar system separation error. Further, it was noted that the tails of the distribution of the radar separation error response measure were not normally distributed.

This Part I report presents a general, abbreviated, nontechnical description of a limited set of results to describe basic trends with maximum simplification; and it includes a minimum of statistical data. More detailed treatments of the large-sample, multidimensional, multivariate experimentations are presented in the associated reports, "Part II: Analyses" and "Part III: Summary."

NA-74-57

A PRELIMINARY COMPARISON OF LABORATORY METHODS FOR ASSIGNING A RELATIVE TOXICITY RANKING TO AIRCRAFT INTERIOR MATERIALS

Joe C. Spurgeon

Final, October 1975 39 P.

(RD-75-37) (AD A018 148)

Thirteen aircraft interior materials have been tested in order to compare the National Bureau of Standards (NBS) smoke chamber and the microcombustion tube furnace as methods for generating toxic combustion gases. The microcombustion tube furnace ranked nitrogen- and chloride-containing test materials of known composition according to the expected order based upon HCN and HCl concentrations. The nitrogen-containing test materials were not ranked in the expected order by measuring peak gas concentrations in the NBS smoke chamber.

Several methods of sampling combustion gases from the NBS smoke chamber have been investigated in an attempt to maximize sample recovery. These methods include colorimetric detector tubes, bag sampling, impinger sampling, and syringe sampling. In general, syringe sampling resulted in the best sample recoveries of the methods tested in this study.

Animal toxicity tests were conducted for nine aircraft interior materials using Sprague-Dawley rats. A relative toxicity ranking of these predominantly nitrogen-containing materials has been determined by exposing the test animals to the combustion products obtained by decomposing the materials in a combustion tube furnace. A preliminary correlation of animal toxicity data with measured gas concentrations indicates that a possible relationship exists between times-to-incapacitation and hydrogen cyanide concentrations produced by the test materials. The coefficient of correlation is 0.93.

NA-74-58

TESTS WITH COAXIAL TACAN ANTENNA AT DOPPLER VERY HIGH FREQUENCY OMNIRANGE (VOR)

Wayne E. Bell

Final, May 1975 55 P.

(RD-75-27) (AD A010 008)

This report describes the performance of Doppler very high frequency omnirange (DVOR) systems with and without a coaxially located tactical air navigation (TACAN) antenna. Flight tests were conducted to determine double-sideband DVOR (DSDVOR) and single-sideband DVOR (SSDVOR) system performance for each condition. Test results show that the error of a SSDVOR station will increase  $\pm 1.8^\circ$  when a TACAN antenna is coaxially located. The DSDVOR system error will increase an average of  $\pm 0.25^\circ$  with the installation of a TACAN antenna coaxially. It is recommended that the TACAN antenna be considered for coaxial location when DSDVOR is used.

NA-74-59

CHARACTERISTICS OF HALON 1301 DISPENSING SYSTEMS FOR AIRCRAFT CABIN FIRE PROTECTION

Constantine P. Sarkos

Final, September 1975 125 P.

(RD-75-105) (AD A017 061)

Two Halon 1301 dispensing systems, modular nozzle and perforated tube, were designed and installed in an obsolete but completely furnished CD7 passenger cabin. For each system, agent distribution was continuously measured during discharge and for a period of 10 minutes at approximately 20 locations throughout the unpressurized cabin. The effect of Halon 1301 discharge on cabin temperature, noise, pressure, and visibility was also measured. The modular system was judged to be best by virtue of its producing more rapid and effective agent distribution resulting in greater potential fire-protection capability. Installation of the Halon 1301 dispensers along the ceiling for both systems minimized the known possible transient adverse effects upon passengers from agent concentration overshoot, discharge noise, overpressure, and reduced temperature. Halon 1301 was found to rapidly permeate all cabin airspaces, including those shielded from the discharge streamlines. The effect of agent leakage through opened emergency exits was investigated. It was determined that even under such unfavorable conditions of operation, a high-rate discharge system would provide a reasonably good degree of inerting protection over a representative evacuation period.

NA-74-60

POWER INTERRUPT EQUIPMENT

Paul John O'Brien

Final, May 1975 25 P.

(RD-75-63) (AD A010 009)



Special test equipment was designed and fabricated at the National Aviation Facilities Experimental Center (NAFEC) to create controlled power interruptions to Federal Aviation Administration (FAA) electronic equipment. The test equipment, designated Power Interrupt Equipment (PIE), interrupts and restores power at precise phase angles. This capability enables specific types and periods of outage to be caused so that outage effects on the unit or system under test can be analyzed. Maximum inrush current can also be produced so that its effect on circuit breakers and the operation of the unit or system under test can be analyzed. PIE was found capable of satisfying the requirements for interrupting and restoring power at precise phase angle. This test equipment facilitates test and evaluation of FAA equipment with respect to the capability of handling power interruptions.

NA-74-61

OCULOMETER MEASUREMENT OF AIR TRAFFIC CONTROLLER VISUAL ATTENTION  
Gloria Karsten, Bernard Goldberg, Richard Rood, and Richard Sulzer  
Interim, February 1975 26 P.  
(AD A006 695)

To evaluate the Oculometer as a visual fixation measuring device for man/machine interface investigations, six air traffic controllers performed simulated radar control functions. A seventh controller performed the control tasks, while both an Oculometer record and a manual record were made of visual attention. It was found that all the controllers spent approximately 80 percent of the test time looking at the radar display, with a mean of 76 glances at the display per 15-minute session. Average glance duration was 10 seconds. Approximately 11 percent of the remaining time was spent looking at the flight progress strips, less than 5 percent looking at the computer input keyboard, and less than 3 percent looking at miscellaneous or indeterminate objects. No marked differences appeared in the scores of individual controllers although they had been selected to represent a diversity of air traffic control experience. In the comparison of methods of recording visual performance, good agreement was obtained between the Oculometer and manual kymograph recorder on time spent looking at the radar, flight strips, and keyboard. The Oculometer was capable of recording brief eye movements and additional detail which was difficult if not impossible with the manual observation method. This additional precision of recording was accompanied, however, by an additional workload in data reduction. It was concluded that the Oculometer has the potential to produce reliable and accurate information when used within the limits of its design. The addition of automatic output of coordinates of fixation would be a valuable improvement resulting in reduced test workload.

NA-74-150

TEST REPORT RADIOFREQUENCY INTERFERENCE/ELECTROMAGNETIC INTERFERENCE MEASUREMENTS  
OAKLAND AIR ROUTE TRAFFIC CONTROL CENTER  
Margaretta V. Stone  
Final Report, May 1974 209 P.  
(RD-74-28) (AD 779 746)

This report describes electromagnetic interference tests at the Oakland Air Route Traffic Control Center (ARTCC), Oakland, California. The tests included measurement of radiated and conducted emission from both the automated system and nonautomated equipments, and radiated and conducted susceptibility of the automated system.

Conducted and radiated electric and magnetic field emission from most of the automated system equipments exceeded the limits of MIL-STD-461A, but was not sufficiently high to adversely affect other equipment certified to MIL-STD-461A. Most of the automated system equipments met the susceptibility limits of MIL-STD-461A. Exceptions were the Plan View Display, Common Logic Unit, Tape Drive, MI display and System Control Console.

It was concluded that the automated system equipment would not adversely affect the performance of other equipment used in its vicinity, provided that the other equipment met the susceptibility requirements of MIL-STD-461A or equivalent specifications. It was further concluded that the automated system is unlikely to be affected by electromagnetic interference generated within a typical ARTCC site, although radiated and conducted emission from the non-automated equipment at the Oakland site exceeded MIL-STD-461A limits. It was recommended that revised emission and susceptibility limits be developed to reflect the specific requirements of FAA ARTCC sites.

NA-74-156

TEST REPORT - RADIOFREQUENCY INTERFERENCE/ELECTROMAGNETIC INTERFERENCE MEASUREMENTS  
NEW YORK AIR ROUTE TRAFFIC CONTROL CENTER

Margaretta V. Stone

Final Report, August 1974 199 P.

(RD-74-110) (AD 784 340)

This report describes electromagnetic interference tests at the New York Air Route Traffic Control Center (ARTCC), Islip, Long Island, New York. The tests included measurement of radiated and conducted emission from both the automated system and non-automated equipments, and radiated and conducted susceptibility of the automated system.

Conducted and radiated electric and magnetic field emission from most of the automated system equipments exceeded the limits of MIL-STD-461A, but was not sufficiently high to adversely affect other equipment certified to MIL-STD-461A. Most of the automated system equipments met the susceptibility limits of MIL-STD-461A. Exceptions were the Plan View Display and Input/Output Control Element.

It was concluded that the automated system equipment would not adversely affect the performance of other equipment used in its vicinity, provided that the other equipment met the susceptibility requirements of MIL-STD-461A or equivalent specifications. It was further concluded that the automated system is unlikely to be affected by electromagnetic interference generated within a typical ARTCC site, although radiated and conducted emission from the non-automated equipment

at the New York site exceeded MIL-STD-461A limits. It was recommended that revised emission and susceptibility limits be developed to reflect the specific requirements of FAA ARTCC sites.

NA-74-167

BOEING 747-100 BOMB LOCATION STUDY

Jack Avery, Bill Chang, and Ray White

Final, December 1974 52 P.

(RD-74-201)

This report covers an analytical study to determine the least risk location on a 747-100 airplane for positioning a discovered explosive device. The study consisted of (1) a review of existing methods of predicting blast effects on typical aircraft structure, (2) selecting candidate locations, (3) determining the aircraft's capability for continued safe flight with minimum and maximum damage at the candidate locations, and (4) developing procedures which would provide the best chance of a safe landing in the event of detonation. The study concludes that a location on the bustle of the number 5 main entry door would be the least risk location, that the aircraft would survive maximum predicted damage at either door examined, that the electronic rack would collapse under minimum damage at the electrical/electronic access door making this location unsuitable.

NA-74-168

LOCKHEED L-1011 SAFE BOMB LOCATION STUDY

E. J. Himmel, M. D. Lamoree, J. E. Doyle, and E. G. Reed

Final, December 1974 92 P.

(RD-74-202)

An analytical study was made to determine the safest location within the Lockheed L-1011 commercial aircraft where an explosive device could be placed should the device be discovered on board the aircraft. A review was conducted of existing methods and data relating to the effects of explosive detonation within an aircraft. Three candidate locations were analyzed to determine: (1) blast loadings; (2) damage to structure, aircraft systems, and controls, (3) passenger and crew injury; (4) residual strength of damaged structure, and (5) aircraft systems and controls effectiveness following the blast.

The study concludes that the safest place to put the bomb is on the underfloor galley service door. A close second safest location is on the aft cargo door. The third choice is the right hand mid-cabin passenger door. The latter location, however, entails high risk of injury to passengers. Procedures to be followed when a bomb is believed to be on board are recommended.

NA-74-169

ELECTROMAGNETIC INTERFERENCE MEASUREMENTS IN ELECTRONIC VOICE SWITCHING EQUIPMENT AREAS

Margaretta V. Stone

Final Report, March 1975 74 P.

(RD-75-28) (AD A008 925)

This report describes a measurement program, performed to determine electromagnetic interference characteristics of spaces in the Denver ARTCC and at the Millville, NJ RCAG site, where components of the Electronic Voice Switching (EVS) system may be installed. Test areas included an EVS Junction module area an EVS back room equipment area (both at the Denver ARTCC) and an EVS RCAG equipment area at the Millville, NJ site. In the junction module area, all magnetic and electric field emission was above MIL-STD-461A emission and susceptibility test limits. In the back room area, magnetic emission was below MIL-STD-461A emission and susceptibility test limits. Narrowband electric field emission in the back room area was above both the MIL-STD-461A emission limit and an extrapolated susceptibility limit of 120 dBuV/M/MHz. In the RCAG area, both transient and steady-state magnetic emission was below MIL-STD-461A emission and susceptibility limits, but all electric field emission (broadband, narrowband and transient) was above MIL-STD-461A emission limits and the susceptibility limits of 120 dBuV/M and 120 dBuV/M/MHz. It is therefore recommended that the EVS system be subjected to electromagnetic interference susceptibility tests (MIL-STD-462 Methods RS01 and RS03) prior to installation in operational sites. Recommended susceptibility test signal levels and frequencies, based on measured levels of steady-state and transient signals at the Denver and Millville sites, are included in this report.

NA-74-172

SIMULATION MODEL FOR NEW YORK AIR TRAFFIC CONTROL COMMUNICATIONS

J. S. Hunter and D. A. Hsu

Interim, February 1975 240 P.

(RD-74-203) (AD A006 426)

This volume describes the construction, validation, and application of a simulation model for air traffic control (ATC) communications. The model is based upon an extensive statistical analysis of voice communications data gathered over the New York area during a busy 2-hour period. The structure of the simulation model is discussed along with the associated GPSS V program. The input parameters are outlined, and various master tables and equations are employed to capsule the information provided by the earlier statistical analyses. Methods for validating the simulation model are described for particular sectors and sector functions. A new statistical testing procedure for comparing both simulated and historical time series traces is evoked. The responses of major interest are the aircraft loading, channel utilization, and communications queuing, the last of which can only be secured through simulation. The explosive nature of the responses under heavy traffic densities is noted, and a new method is employed for determining the probability of the onset of such unstable conditions. Three time series responses are studied to determine their coupling. Additional studies concerning ATC network capacity, inter-communication gaps, and alternative distributions for responses are also included.

NA-74-174

RADIOFREQUENCY INTERFERENCE (RFI)/ELECTROMAGNETIC INTERFERENCE (EMI)  
MEASUREMENTS

Margaretta V. Stone

Final, August 1972 - July 1973 380 P.

(RD-75-30) (AD A008 439)

This report describes electromagnetic interference tests at three Air Route Traffic Control Centers (ARTCC's). These were the Los Angeles ARTCC, Palmdale, California, the Oakland ARTCC, Fremont, California, and the New York ARTCC, Islip, Long Island, New York. The tests included measurement of radiated and conducted emission from both the automated system and nonautomated equipments, and radiated and conducted susceptibility of the automated system.

Conducted and radiated emission from most of the automated system equipments exceeded the limits of MIL-STD-461A, but was not sufficiently high to adversely affect other equipment certified to MIL-STD-461A. Exceptions were the Plan View Display, Common Logic Unit, Tape Drive, MI display, System Control Console, Non Radar Keyboard Multiplexer, Input/Output Control Element, Data Receiver Group and FR-1800 recorder.

It was concluded that the automated system equipment would probably not affect the performance of other equipment used in its vicinity, provided that the other equipment met the susceptibility requirements of MIL-STD-461A or equivalent specifications. It was further concluded that the automated system is unlikely to be affected by electromagnetic interference generated within a typical ARTCC site, although radiated and conducted emission from the non-automated equipment at the three sites exceeded MIL-STD-461A limits. It was recommended that revised emission and susceptibility limits be developed to reflect the specific requirements of the ARTCC sites.

NA-74-175

DEVELOPMENT OF A SCIENTIFIC BASIS FOR ANALYSIS OF AIRCRAFT SEATING SYSTEMS

David H. Laananen, Ph.D.

Final, August 1972 - April 1974 213 P.

(RD-74-130) (AD A004 306)

A three-dimensional mathematical model of an aircraft seat, occupant, and restraint system has been developed as an aid to the development of crash-worthy seats and restraint systems for general aviation aircraft. The occupant model consists of eleven rigid mass segments whose dimensions and inertial properties have been determined from studies of human body anthropometry and kinematics. The seat model is made up of beam and membrane elements with provision for simulating plastic behavior by the introduction of plastic hinges in the beams.

A user-oriented computer program called Seat Occupant Model-Light Aircraft (SOM-LA) based on the three-dimensional model has been developed for use by engineers concerned with design and analysis of general aviation seats and

restraint systems in that detailed descriptions of both are used as input. The response of the seat and occupant, restraint system loads, and various injury criteria are predicted for any given set of crash conditions.

NA-74-177

EVALUATION OF THE RUBINO PROCEDURE FOR RADIO TELEMETRIC THEODOLITE POSITIONING (REVISED)

D. S. Lerner

Final, October 1974 46 P.

(EM-74-17) (AD A004 317)

This report presents the results of an evaluation of a procedure described in "Working Paper on Radio Telemetric Theodolite (RTT) Positioning" by Joe Rubino, AEM-200, dated April 1973. An analysis and evaluation was conducted by gathering information about the present glide slope system, difficulties that had been encountered, and changes that had been implemented. The analysis performed indicates that all factors affecting the glidepath are separated by the Rubino RTT placement into path structure (indicated by the flight recording), and the threshold crossing height (which is incorporated into the RTT placement). This study evaluation concludes that because of this separation the Rubino procedure is better because it provides a better description of the glidepath in space.

NA-75-1

INVESTIGATION OF FACTORS INFLUENCING PROPELLER BLADE FAILURES

Marvin J. Walker

Final, July 1975 93 P.

(RD-75-84) (AD A013 918)

A flight and ground test program was conducted to examine vibratory and steady propeller blade operation stresses occurring in normal and transient abnormal operation of several types of reciprocating engine powered general aviation aircraft.

The objectives of the tests were to evaluate such stresses as a possible cause of early propeller blade fatigue failure and to determine whether they were inherent in the characteristics of the engine-propeller combinations or attributable to such factors as tolerance spread between identical models or accumulated time in service.

The results also were considered in respect to current design and certification standards.

NA-75-3

MEASUREMENT OF THE TRAILING VORTEX SYSTEMS OF LARGE TRANSPORT AIRCRAFT, USING TOWER FLY-BY AND FLOW VISUALIZATION. (SUMMARY, COMPARISON AND APPLICATION)

Leo J. Garodz, David M. Lawrence and Nelson J. Miller

Final, January 1976 160 P.

(RD-75-127) (AD A021 305)

Full-scale flight test investigations have been made of the characteristics, persistence and movement of the trailing vortices generated by propeller and jet transport aircraft. The tests were performed by the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, during the period 1970-1973, using tower fly-by and vortex flow visualization. The results are summarized and comparisons made of the vortices of the Douglas DC10, DC9, and DC7; Boeing 747, 727, and 707; Lockheed C5A, C141, and L1011; and the Convair 880 aircraft. Vortex mathematical models and decay mechanisms are discussed and their effects (upset potential) on encountering aircraft are investigated for possible air traffic control application.

NA-75-4

RUNWAY SURFACE FRICTION CHANGES DUE TO HIGH-PRESSURE WATER-JET RUBBER REMOVAL, CHARLESTON AIRPORT, CHARLESTON, SOUTH CAROLINA

William A. Hiering and Charles R. Grisel

Interim, August 1975 21 P.

(RD-75-103) (AD A013 993)

The subject effort was to determine if the utilization of a new method of removing rubber deposits from an airport runway would change the surface friction of that runway. The method consisted of jetting water at high velocity to hydraulically remove the rubber from the surface. The results of these tests indicated that the equipment used by the runway-cleaning contractor did not damage the runway surface; however, it did not appreciably change the friction characteristics, probably due to the incomplete removal of all rubber deposits.

NA-75-5

LABORATORY MEASUREMENTS OF VERY HIGH FREQUENCY COMMUNICATION EQUIPMENT FOR DATA LINK

Anthony Swezeny

Interim, October 1975 211 P.

(RD-75-159) (AD A018 721)

Laboratory measurements were made on very high frequency (vhf), commercial airborne transceivers and Federal Aviation Administration (FAA) vhf ground transmitters and receivers. Characteristics of each unit were measured in order to determine suitability for data link application and to provide a data base for subsequent planning of vhf data link flight tests.

Results show that Aeronautical Radio, Inc. (ARINC), transceivers are suitable data link devices and with minor modifications most FAA and general aviation transmitters and receivers tested are also suitable at the 2400 and 4800 bit per second rates.

NA-75-6

LABORATORY TESTS OF A DATA LINK MODEM

Joseph A. Bilello

Final, September 1975 24 P.

(RD-75-134) (AD A017 165)

This report evaluates the performance of two minimum shift key (MSK) modulation modems designed for a very high frequency (vhf) data link communications. Tests consisted of determining the probable bit error of two modems on a loop-around mode for each modem and then in a back-and-forth mode between the two modems. For each of these two test conditions, the modems were subjected to various signal-to-noise (S/N) ratios at the data rates of 2400 and 4800 bits/second (b/s). Each test was terminated after 800 bit errors were accumulated, except for those test runs where the modem was running essentially error free, the test period was limited to a 24-hour period. Results indicated that the performance of each modem was the same over the S/N ratios used, within a  $\pm 1$ -dB S/N tolerance.

NA-75-7

EVALUATION OF DISTRIBUTION-FREE QUANTIZER, SEVERAL RANGE BINNING TECHNIQUES, AND AN EXTENDED RANGE MOVING TARGET INDICATOR VIDEO

Martin Holtz and Leo Wapelhorst

Interim, November 1975 113 P.

(RD-75-185) (AD A019 337)

This report contains the results of tests that were conducted to determine the performance of a radar quantizer having distribution-free characteristics as compared to that of an existing type of quantizer employing mean level techniques. Several types of range binner were developed and tests were performed to ascertain the false target rate and detection capabilities of each of the quantizer and range binner configurations. The tests consisted of both bench tests and those employing weather clutter samples from the National Aviation Facilities Experimental Center (NAFEC) ASR-5 environment. Additionally, performance of the radar processor with inputs derived from a moving target indicator (MTI) video, that was designed to have an extended dynamic range, was investigated.

It was concluded that the design of the rank order quantizer described in this document approaches theoretical performance. Detection loss is experienced at range cell boundaries. The extended range MTI provides comparable performance to that of MTI log but is far less costly. Additionally, second threshold control is capable of maintaining a false target rate acceptable as an input to a tracking algorithm.

NA-75-8

FRANGIBILITY TESTS OF EXISTING APPROACH LAMPS AND HOLDERS

Bret B. Castle

Interim, August 1975 42 P.

(RD-75-97) (AD A013 995)

Tests were conducted on approach lamps and holders to determine to what extent current designs are frangible. A catapult accelerated the fuselages of two



widely used types of small aircraft to collision with PAR-38 and PAR-56 lamps and associated holders. A total of 53 runs at different speeds and with different exposed lamp face orientations resulted in evidence that most small, general aviation aircraft windshields will shatter with lamp penetration at less than flying speeds. Results show that a safety redesign of the lamps might reduce penetration probability and result in a lamp that will not penetrate windshields at less than approach landing speeds.

NA-75-10

SULFUR OXIDE MEASUREMENT IN AIRCRAFT TURBINE ENGINE EXHAUST

G. R. Slusher

Interim, September 1975 16 P.

(RD-75-101) (AD A016 447)

A limited investigation was conducted to measure the oxides of sulfur in aircraft turbine engine exhaust. The objective was to establish the ratio of sulfur trioxide ( $\text{SO}_3$ ) to sulfur dioxide ( $\text{SO}_2$ ) to be utilized in support of the climatic impact assessment program. The  $\text{SO}_3$  concentration was found to be 13.8 percent to the  $\text{SO}_2$  concentration as determined by wet chemistry analysis. Sulfur recovered in the samples was approximately 50 percent of the total sulfur in the fuel.

NA-75-12

ANALYTICAL STUDY OF MIXED-FLOW JT8D EXHAUST EMISSIONS MEASUREMENTS FOR FIXED-PROBE REQUIREMENTS

Gerald R. Slusher

Final, October 1976 34 P.

(RD-76-140) (AD A033 121)

A method is outlined to optimize the shape, size, and location of fixed probe for acquiring representative emission samples from the exhaust of a mixed-flow JT8D-11 turbofan engine. Families of geometric shapes and mutually exclusive probe configurations are overlaid upon a 177-point traverse grid. A significance ratio is calculated and used to rank results. Representative and non-representative areas of the exhaust plume are defined. Probe configurations are overlaid upon the traverse grid and ranked to obtain a representative configuration. An area of the JT8D exhaust plume suitable for acquiring representative emission samples was found which reduces the overall 177 sample points to 20 sample points.

NA-75-14

ABBREVIATED FULL-SCALE FLIGHT TEST INVESTIGATION OF THE LOCKHEED L1011 TRAILING VORTEX SYSTEM USING TOWER FLY-BY TECHNIQUE

Leo J. Garodz

Final, May 1976 219 P.

(AFS-1-76-2) (AD A028 095)

A brief flight test program was conducted at the National Aviation Facilities

Experimental Center (NAFEC) to investigate the time-history characteristics of the vortex system of a Lockheed L1011 airplane in terminal area-type operations using a 140-foot high instrumented tower. Vortex rotational flow velocities were measured by hot-film anemometers, vortex flow visualization--as outlined by tower-mounted smoke grenades--was documented, and meteorological data was recorded. In addition, data on aircraft track, performance, and configuration were gathered. The test results show that: (1) the L1011 vortex system was more persistent and intense than that of other heavy jet transport (300,000 lb) aircraft tested by NAFEC, but did not persist for more than 2 minutes; (2) vortex dissipation was due primarily to vortex breakdown (bursting); (3) vortex core diameters were on the average about 5, 4, and 2 feet in diameter for the landing, approach, and takeoff configurations, respectively; (4) peak recorded tangential velocities,  $V_\theta$ , were 126, 135, and 224 feet per second for these same respective configurations; (5) vortex lateral movement in-ground effect was approximately  $(\pi/6.6)b$ , above ground level; and (6) average vortex descent velocities approached 6 feet per second out of ground effect.

NA-75-17

COMPUTER DISPLAY CHANNEL OR 9020E COMPUTER SIMULATOR INTERFACE DEVICE

John D. Riley

Final, November 1975 106 P.

(RD-75-192) (AD A019 338)

The Computer Display Channel or 9020E Computer Simulator Interface Device (CESID) was designed and fabricated to simulate computer display channel or 9020E computer output status messages to the systems maintenance monitor console for the purpose of verifying that the systems maintenance monitor console conformed with its test specification. The CESID permits testing of the systems maintenance monitor console without interference to the computer display channel or the 9020E computer.

The CESID performed well in Systems Integration National Airspace Equipment tests of the systems maintenance monitor console.

The CESID is an excellent trouble-shooting tool for computer display channel or 9020E computer monitoring portions of the systems maintenance monitor console.

NA-75-18, Volume I

INVESTIGATION OF PILOT SELF-BRIEFING TECHNIQUES VOLUME I, METHODOLOGY, RESULTS, AND RECOMMENDATIONS

Hugh D. Milligan and Bruce L. Rosenberg

Interim, February 1976 85 P.

(RD-75-90 Volume I) (AD A024 645)

A study was conducted to assess the usefulness of automation techniques and devices developed for the purpose of providing pilots with the capability to obtain preflight weather briefings without the aid of a flight service station spe-

ialist. Both live and canned weather data were employed during the conduct of the study to ascertain the validity of the basic concepts and to define improvements thereto. The data elicited from the activities, thus far, indicates that pilot self-briefing is a feasible approach which portends delivery of quality weather briefings with a concomitant cost reduction when compared to the cost of today's and any future labor intensive briefing system. This is a technical report containing information on design of the experiment, data collected, statistical analyses of results, and a summary narrative, conclusions and recommendations.

Volume I contains the textual presentation of the experiments as well as the analyses and some tables presenting overall pilot responses.

Volume II, appendixes, contains samples of the various briefings, the questionnaires used, and the pilots' responses where they opted to do so.

NA-75-18, Volume II  
INVESTIGATION OF PILOT SELF-BRIEFING TECHNIQUES VOLUME II, APPENDIXES  
Hugh D. Milligan and Bruce L. Rosenberg  
Interim, February 1976 150 P.  
(RD-75-90, Volume II) (AD A022 075)

A study was conducted to assess the usefulness of automation techniques and devices developed for the purpose of providing pilots with the capability to obtain preflight weather briefings without the aid of a flight service station specialist. Both live and canned weather data were employed during the conduct of the study to ascertain the validity of the basic concepts and to define improvements thereto. The data elicited from the activities, thus far, indicates that pilot self-briefing is a feasible approach which portends delivery of quality weather briefings with a concomitant cost reduction when compared to the cost of today's and any future labor intensive briefing system. This is a technical report containing information on design of the experiment, data collected, statistical analyses of results, and a summary narrative, conclusions and recommendations.

Volume I contains the textual presentation of the experiments as well as the analyses and some tables presenting overall pilot responses.  
Volume II, appendixes, contains samples of the various briefings, the questionnaires used, and the pilots' responses where they opted to do so.

NA-75-19  
STUDIES OF SUBMINIATURE LAMPS USED FOR INDICATION PURPOSES IN THE SYSTEM  
MAINTENANCE MONITOR CONSOLE  
Art Moss, Lane Hinkley, and Dr. Helen W. Hamilton  
Final October 1975 30 P.  
(RD-75-168) (AD A017 064)

The type 247 subminiature lamps which are currently used in the projection

readout indicators (PRI's) of the system maintenance monitor console (SMMC) have been failing at an average rate of two per day per AMMC. Furthermore, this particular lamp type is available from only one source. Consequently supply problems have been experienced.

Because of these problems, several other types of subminiature lamps were investigated to determine their suitability as replacements for the incumbent type 247. Tests were performed to determine their relative mean lifetimes, as well as their general acceptability from a standpoint of brightness. From an overall viewpoint, considering cost, availability, mean life, and acceptable brightness, the type 685 subminiature lamp was found to be the most suitable replacement for the type 247, provided, during the transition replacement period, they are not mixed with the brighter type 247's in the color positions of the PRI's.

NA-75-20

RUNWAY FRICTION CHANGES DUE TO HIGH-PRESSURE WATER-JET CLEANING OPERATIONS,  
HOUSTON INTERCONTINENTAL AIRPORT, HOUSTON, TEXAS

W. A. Hiering and C. R. Grisel

Interim, September 1975 21 P.

(RD-75-129) (AD A014 641)

The subject effort was to evaluate a new method of removing rubber from airport runways in terms of its effect on runway surface friction. This rubber removal method consisted of jetting water at high velocities to remove the rubber deposits from the surface. The results of the tests indicated that the contractor's equipment and method of operation removed all the above-the-surface rubber deposits, did not visibly damage the runway surface, and increased friction in the rubber-laden aircraft touchdown areas.

NA-75-21

TERMINAL INFORMATION PROCESSING SYSTEM CONCEPT TESTING (CONTROL TOWER)

Hamilton T. Rohland, Theodore W. Rundall, and Michael J. Verno

Final, September 1976 39 P.

(RD-76-143) (AD A031 151)

Simulations were conducted at the National Aviation Facilities Experimental Center using the Flight Data Distribution System to evaluate two concepts of a Terminal Information Processing System (TIPS) using electronic display of flight information as a replacement for printed paper flight strips in airport traffic control towers associated with high-density Automated Radar Terminal System (ARTS III) facilities. It was concluded that paper flight strips can be replaced successfully by an electronic system. Recommendations were made to remedy those deficiencies that were discovered during the concept testing.

NA-75-22

RADAR BRIGHT DISPLAY EQUIPMENT (RBDE-4 AND RBDE-6) SCAN CONVERTER FOCUS  
IMPROVEMENT MODIFICATION

John W. Aschenbach

Final, May 1975 35 P.

(RD-75-76)

An evaluation of a modification kit designed to improve the focus and thereby upgrade the performance of the Radar Bright Display Equipment (RBDE)-4 and RBDE-6 scan converter was conducted at the National Aviation Facilities Experimental Center (NAFEC) employing the RBDE Test Facility and Radar Support Site.

The results of the RBDE-4 focus modification showed sufficient improvement of focus on the controller's display to justify field implementation. Although the RBDE-6 focus modification showed a slight engineering improvement, there was not sufficient displayed improvement to justify field implementation; however, this approach should be considered if future focus problems occur.

NA-75-23

TEST AND EVALUATION OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM ELECTRONIC  
SCAN ANTENNA (SPECIFICATION TESTS)

Anthony D. Bradley

Interim, January 1976 85 P.

(RD-75-212) (AD A012 062)

The air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) consists of 56 array modules placed on a platform (ring) constructed around the top of an airport surveillance radar tower. A shelter beneath the tower provides an enclosure for the control and radiofrequency (RF) distribution system of the ESA.

This interim report covers the specification tests to determine compliance with portions of the engineering requirement applicable to field testing.

It was concluded that the ESA performed the basic functions of beam stepping, agile beam repositioning, beam hopover and the generation of side-lobe suppression (SLS), improved SLS (ISLS), sum channel, and difference channel antenna beam pattern characteristics. The data obtained during the effort met the specification requirements, taking into account field environmental effects.

NA-75-25

INVESTIGATION OF AIRCRAFT FUEL TANK EXPLOSIONS AND NITROGEN INERTING REQUIREMENTS  
DURING GROUND FIRES

Richard Hill and George R. Johnson

Final, October 1975 98 P.

(RD-75-119) (AD A021 665)

Nitrogen inerting was investigated as a means of preventing or minimizing ex-

plosions and/or reactions in aircraft fuel tanks under simulated crash-fire conditions. Tests were conducted on both small and large volume tanks, inerted to various concentrations (expressed in terms of O<sub>2</sub> concentration by volume), containing different amounts of Jet-A or JP-4 fuel and heated at different rates.

Results of these tests indicated that internal fire or explosion would not result from external heating or internal high-energy spark when the tank was inerted to an oxygen concentration lower than 10 percent.

NA-75-26

ENROUTE SECTOR REDESIGN (FIELD SURVEY OF FLIGHT STRIP DATA)

Richard L. Sulzer and Robert J. Lucas

Interim, September 1975 26 P.

(RD-75-138) (AD A016 665)

A flight data survey has been conducted at eight air route traffic control centers to identify sector flight data requirements when operating with National Airspace System Stage A radar data processing (RDP). Controllers stated which flight data elements, presently shown on paper flight strips, are required for continuous display when using RDP, and which elements can be deleted from display or placed on a callup status in a redesigned enroute sector. The results of this survey and a concomitant analysis of hand annotation of control information on the strips are intended to guide design of a testable and improved display that can replace the paper strips. Procedures to be followed in demonstrating the potential utility of such a reformatted and automated display of flight data are summarized. Also, tests to be conducted with improved data input facilities are described.

NA-75-27

TEST AND EVALUATION OF THE CONFLICT ALERT FUNCTION (HIGH ALTITUDE) WITH THE NAS ENROUTE A3d2.1 SYSTEM

Frederick W. Ranger

Interim, August 1975 24 P.

(RD-75-117) (AD A014 103)

This report describes the operational evaluation of the conflict alert function when interfaced with the National Airspace System (NAS) Enroute A3d2.1 system. Tests were conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in a beacon only high-altitude environment with simulated digital target data. Tests were designed to evaluate the performance of the conflict alert function with respect to detection capability and adequacy of warning provided. Tests were conducted in two modes of operation: A "conflict alert warning only" mode in which controllers took no action to resolve potential conflicts without waiting for an alert to be generated. Results indicate that the conflict alert function is operationally suitable when integrated with the A3d2.1 system. Some false or late alerts could occur due to the lag between the velocity vector and the true aircraft heading. For certain situations the warning time provided may not be the optimum. False alerts, though distracting

did not derogate the desirability of having the conflict alert function as a backup for the controller.

NA-75-28

VISUAL ATTENTION OF PRIVATE PILOTS, THE PROPORTION OF TIME DEVOTED TO OUTSIDE THE COCKPIT

Richard L. Sulzer and Gerald E. Skelton

Final May 1972 - March 1975 25 P.

(RD-76-80) (AD A025 468)

The direction of the pilot's visual attention was recorded during three series of flights in a small aircraft. It was found that pilots using visual flight rules (VFR) spent approximately 50 percent of the time looking outside the cockpit, an airsearch time much higher than previously recorded for air-carrier cockpits. The remainder of the time, while occupied in the cockpit, the pilot might be likely to miss seeing an approaching aircraft. Hence, a test environment for pilot warning systems intended to aid visual detection of potential threats should employ a pilot workload that produces a realistic proportion of visual attention available for outside search

NA-75-29

DATA LINK SUBSYSTEM LABORATORY TESTS

Anthony J. Swezeny

Final, October 1974 - November 1974 16 P.

(AD A033 050)

Various very high frequency (VHF) transmitter-receiver combinations were used with minimum shift key (MSK) modems for bit error rate tests at 2400 and 4800 bit/second (b/s) rates and at various radiofrequency (RF) noise density levels over a simulated RF digital data link. Results indicated that to obtain the same bit error rate performance, the energy to noise (E/No) requirements differed up to 3.5 dB at 2400 b/s and up to 6 dB at 4800 b/s for the various transmitter-receiver combinations in the ground/air channel.

NA-75-35

RECOMMENDED IMPROVEMENTS FOR TRANSMISSOMETER INSTALLATIONS

Warren Smith

Final, June 1974 - November 1974 20 P.

(RD-75-167) (AD A024 476)

Field reports of operational deficiencies in the type FA 7861 transmissometer were investigated in order to define problem areas. Contingent with defining the problems, solutions were sought to eliminate or minimize the problems. Weather-related transmissometer outage reports and questionnaires on transmissometer RVR outages were reviewed. Phone calls and visits to Airways Facilities transmissometer technicians were made. Results indicate that the transmissometer system is reliable, but requires constant attention. Major

problems are (1) contamination of the projector lamp, (2) inability of the system to self-calibrate, and (3) snow in the receiver barrel. Recommended solutions for these problems are (1) use of a redesigned hood assembly for increasing projector protection, (2) use of a portable laser system, now in production, for calibration, and (3) use of wind baffles and/or heavy-duty purging blowers for receiver protection. Minor problem areas and possible solutions are also discussed.

NA-75-36

JET BLAST FENCE INVESTIGATION AT JOHN F. KENNEDY INTERNATIONAL AIRPORT

Guenther H. Christiansen

Final, August 1975 32 P.

(RD-75-121) (AD A015 086)

A blast fence installed at the departure end of runway 31L at John F. Kennedy International Airport intended to protect aircraft landing on runway 4R from the effects of jet blast was believed to be ineffective. Tests were conducted in two phases. The initial phase was subjective, using smoke to aid in flow visualization. These tests were inconclusive and led to a second phase using instrumentation to determine whether or not a jet blast was present on runway 4R behind the blast fence. Results of phase II confirmed the presence of a jet blast. Tests covered seven aircraft types and indicated maximum blast velocities at runway 4R of 35 miles per hour above ambient wind.

NA-75-37

RELIABILITY ANALYSIS OF THE 9020A AND 9020D CENTRAL COMPUTER COMPLEX AT THE NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER

Arthur R. Moss

Final, November 1975 70 P.

(RD-75-175) (AD A020 160)

The reliability of the 9020A and 9020D versions of the Central Computer Complex (CCC) located at the National Aviation Facilities Experimental Center (NAFEC) was assessed for periods of 3 and 1 years, respectively. This reliability was expressed in terms of the mean uptime (MUT), mean downtime (MDT), and mean time between failures (MTBF) of two system modes (A1 and C1) made up of the same subsystems but containing different numbers of operating and redundant elements in the subsystems. The 9020A was subjected to a 1-year official reliability test. Results indicate the MUT and MTBF for the A1 mode exceeded the contractual requirements by factors of 14.6 and 4.5 or greater, respectively. The corresponding factors for the C1 mode were 4.14 and 6.15 or greater respectively. The MDT for each mode was within the specified limit. Reliability assessment on the 9020A was continued for an additional 2 years following the completion of the official 1-year test period. Results show that the MUT and MTBF for both 9020A modes, over the combined 3 years of assessment, still greatly exceeded the contractual requirements. The MDT of the A1 mode was within the specified 60-minute maximum; however, the MDT of the C1 mode (39 minutes) exceeded the specified 30-minute maximum. The 9020D, an improved version of the 9020A, was also



assessed for a 1-year period. MUT and MTBF for the A1 mode were at least an order of magnitude above the specification requirements, while the average system MDT (based on nominal values of element MDT) was within the specification requirements. Printed circuit card replacements and other parts replaced as a result of failures occurring during these combined 4 years of observation are also discussed.

NA-75-38

VISUAL GROUND AIDS SURVEY OF JOHN F. KENNEDY INTERNATIONAL AIRPORT

Paul H. Jones

Interim, November 1975 85 P.

(PB 247 169)

The purpose of this report was to document the types of visual ground aids that are presently being used at John F. Kennedy International Airport. The report was done in support of an overall program at the Department of Transportation, Transportation System Center, to develop an airport surface traffic control system.

This survey was accomplished through the help of the Aviation Technical Services Division, Aviation Department, of the Port Authority of New York and New Jersey. Information for this survey was gathered through visitation to the airport, airport drawings, and discussions with Port Authority personnel.

Information from this report will be used to determine the feasibility of installing and operating an airport surface traffic control system.

NA-75-39

EVALUATION OF A VISUAL DEPARTURE PATH INDICATOR

E. Leon Reamer

Final, June 1975 19 P.

(RD-75-99) (AD A013 996)

This report describes the technique used and presents the result of tests that were conducted to evaluate a visual departure path indicator in determining its suitability to prevent spatial disorientation when an aircraft, under visual flight rules, departs from an airport over land or water where no horizon and few visual cues exist. The work involved testing the system at the National Aviation Facilities Experimental Center (NAFEC) to determine if it is an appropriate type of system to use. After a satisfactory testing period at NAFEC the equipment was moved to an airport where spatial disorientation might be encountered and an in-service test was performed at that airport. The result of the tests indicates that the system is on the verge of being satisfactory for the site selected; however, after a critical evaluation it was determined that the system should not be considered for use at airports with similar problems, since a sufficient sampling of pilot comments from inservice testing has not been received. It is anticipated that the data should be available after an extended inservice operational period.

NA-75-40

DEVELOPMENT OF A PERFORMANCE CRITERION FOR ENROUTE AIR TRAFFIC CONTROL PERSONNEL  
RESEARCH THROUGH AIR TRAFFIC CONTROL SIMULATION: EXPERIMENT I--PARALLEL FORM  
DEVELOPMENT

Edward P. Buckley, et al.

Interim, February 1976 62 P.

(RD-75-186) (AD A023 411)

The first of a series of small experiments was performed as part of the process of developing a standardized performance criterion for journeyman enroute traffic controllers. The finally developed performance measurement system will be used in personnel research such as the evaluation of potential aptitude tests as to their capacity to predict suitability for entrance into training.

The criterion measure will be based on the use of realistic dynamic simulation of the radar air traffic control situation. The completed measurement system will be required to possess reliability, objectivity, and relevance of measurement of performance. Another requirement will be the availability of alternate traffic problems which are different but proven to be of equivalent difficulty level.

The purpose of this first experiment was to seek directions for the construction of different but equally difficult (parallel) forms of the test by using combinations of sector geographic structures and traffic density levels. Two sectors, which differed widely in geographic structure, and three traffic density levels were orthogonally combined to yield six experimental conditions. Six experienced air traffic controllers worked under each of the six conditions in the air traffic control simulator. The results indicated that performance scores were much less affected by sector structure than by traffic density. Consequently, it was accepted as a guideline for further work that parallel forms can be built on the basis of traffic density level equivalence alone. This will simplify development of parallel forms of the criterion measure.

NA-75-41

AREA NAVIGATION HIGH-ALTITUDE NETWORK STUDY

Arthur G. Halverson, Floyd B. Woodson, Richard W. Soper, and Henry L. Arch

Final, February 1976 270 P.

(RD-76-6) (AD A023 230)

A high-altitude area navigation (RNAV) network study was conducted at the National Aviation Facilities Experimental Center (NAFEC) in order to (1) apply and evaluate the FAA/Industry RNAV Task Force concepts for RNAV route structures in the high-altitude airspace, (2) offer alternative approaches, where appropriate, and (3) derive data relative to the potential benefits to the air traffic control (ATC) system and to its users by the implementation of RNAV. For design purposes, the enroute structure was based on the requirements for an all-RNAV high-altitude environment starting in 1977. Route structures were evaluated through fast time simulation of a mixed RNAV/VOR environment, with traffic samples representing projected traffic densities for the pre-1977, 1977-1982, and post-1982 time periods with varying mixes of RNAV-equipped aircraft. Alternative route structure design principles were developed which differed from the RNAV Task

Force concepts in (1) the configuration of arrival and departure routing into and out of terminal areas, (2) the use of one-way routes, (3) the use of charted routes versus provision for noncharted offset tracks, (4) the treatment given to traffic from intermediate terminals with respect to nearby flows between more distant terminals, and (5) route width requirements. Results indicate that RNAV offers a potential reduction in workload for the enroute air traffic controller; in particular, the use of one-way, climb and descent route segments should substantially reduce the overtake and head-on problem in the area where aircraft transition to/from enroute altitude. Users of the system should benefit through a reduction in route miles, less delay, and less time spent at undesired altitude.

NA-75-42

TEST AND EVALUATION OF ATCRBS ELECTRONIC SCAN ANTENNA (FIELD ENVIRONMENT TESTS)

Anthony D. Bradley

Interim, January 1976 100 P.

(RD-75-219) (AD A021 771)

The air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) as designed and built consists of 56 array modules placed on a platform (ring) constructed around the top of an airport surveillance radar tower. A shelter beneath the tower provides an enclosure for the control and radio-frequency distribution system of the ESA.

This interim report covers the field environment testing to measure and evaluate the ability of the ESA to overcome siting problems in a representative field environment as compared to the existing ATCRBS in-service antennas (types FA-8043 and FA-8044).

It was concluded that the ATCRBS ESA improved the vertical lobing pattern over flat terrain and provided a matched directional and omnidirectional pattern in comparison with the ATCRBS in-service antennas. However, local environment conditions along one particular radial at the terminal radar/beacon test facility (TR/BTF) caused severe low-elevation angle interference (vertical lobing), and diffraction of the ATCRBS ESA directional and omnidirectional beam patterns were noted from a vertical obstruction.

Beam hopover, combined with improved side lobe suppression (ISLS) system operation, effectively eliminated reflections from a large aircraft hangar building which were present when using the in-service ATCRBS antenna.

NA-75-44

RESULTS OF SIMULATION EXPERIMENTS DESIGNED TO SHOW THE EFFECT OF TONE BURST DISTURBANCE UPON AIR TRAFFIC CONTROL AIR/GROUND COMMUNICATIONS

Robert G. Mulholland

Final, February 1976 41 P.

(RD-75-187) (AD A022 076)

Results of simulation of sectors in the New York Air Route Traffic Control Center (ARTCC), New York Common IFR (instrument flight rules) Room, and terminals within the New York control area are described. The simulation experiments were designed to show the effect of a proposed Federal Communication Commission (FCC) regulation concerning tone burst identification of privately owned transmitters on air traffic control (ATC) air/ground voice communications. The results are presented in 180 pages of output data showing the effect of tone burst duration on communications delay and channel utilization over both long (2-hour) and short (1-minute) term time durations for nine distinct sector types. The unmistakable conclusion is that implementation of the proposed regulation will adversely affect air/ground communications unless some way is found to prevent tone burst identification procedures from extending the duration of pilot-initiated transmissions. For example, observed percentage increases in average channel utilization, i.e., the fraction of a 2-hour period during which the air/ground channel is busy, ranged from 11 to 18 percent when the tone burst length was set at 0.5 second. At tone burst durations of 1.5 seconds, the observed range was 35 to 54 percent. In the case of average communications delay, i.e., the long-term average delay between the instant that the controller or a pilot desires to converse with the other and the time that the channel becomes available, increases of 28 to 80 percent were observed for tone burst durations of 0.5 second, while tone burst lengths of 1.5 seconds raised the average delay by 138 to 475 percent.

NA-75-45

EVALUATION OF THE PRODUCTION IMPROVED RADAR QUANTIZER GROUP MODIFICATION TO THE PRODUCTION COMMON DIGITIZER

William C. Swanseen

Final, May 1976 26 P.

(RD-76-5) (AD A024 750)

An improved radar quantizer group (RQG) was installed in the production common digitizer (PCD) located at the Elwood, New Jersey, National Aviation Facilities Experimental Center long range radar site. The modified RQG improves search target detection in radar clutter environments. A series of subsystem and system tests was conducted to compile data comparing digitizer performance using the improved RQG/PCD with performance from an unmodified PCD. Test results indicate increased search target detection and reduced automatic clutter eliminator (ACE) total blank in weather clutter areas. It was concluded that the modified PCD increased search track life in radar clutter environments.

NA 75-46

TEST AND EVALUATION OF THE BEACON PROCESSING SUBSYSTEM OF THE AUTOMATED RADAR TERMINAL SYSTEM (ARTS III) ALL-DIGITAL TRACKING LEVEL SYSTEM

Martin Holtz and Mark Schoenthal

Final, July, 1976 281 P.

(RD-76-98) (AD A028 514)

This report describes the test and evaluation conducted to determine the per-

formance of the beacon processing subsystem (BPS) of the Automated Radar Terminal System (ARTS III) all-digital tracking level system. A test bed was established to perform an evaluation of the level-one ARTS III system in fiscal year 1973. This included development of statistical reduction programs to provide summary data defining system performance. The level-one beacon ARTS III report (FAA-RD-73-182) contains the results and conclusions of that study from which a baseline standard of performance has been established. The test bed and reduction program interface were modified to accommodate the improved beacon data acquisition subsystem (BDAS). Technical tests were conducted using special test equipment to determine the characteristics of the improved BDAS and improved software. These tests included wide pulse detection, garble detection, code validation, processor loading, probability of detection, false alarm rates, and defruiter performance. Actual target data within the National Aviation Facilities Experimental Center (NAFEC) environment were processed to determine the effect of various system configurations. It was concluded that system performance of the BPS is superior to that achieved with the level-one ARTS III system. This is particularly true in the areas of pseudoleading-edge detection, garble recognition and input-output processor (IOP) processing efficiency. Incorporation of a minimum-hit threshold of three enhanced performance of the system for undefruited inputs. Overall performance was significantly degraded for system configurations employing a defruiter function. However, processor loading was far less for defruited replies.

NA-75-47

EVALUATION OF THE MODIFIED NAS EN ROUTE STAGE A MODEL 3D WEATHER AND FIXED MAP UNIT

Robert W. Delaney

Final, March 1976 64 P.

(RD-76-53) (AS A024 330)

A number of changes were requested by Air Traffic Service to improve the operational performance of the National Airspace System (NAS) En Route Stage A Model 3D Weather Subsystem, the basic element of which is the Weather and Fixed-Map Unit (WFMU). The essential changes included an increase in the WFMU weather-processing range to 200 miles, an improvement in the azimuth resolution of weather contour presentation; and provision for finer threshold adjustments for display of weather contours at different attenuation levels. Several technical and operational tests were performed at Elwood, New Jersey, and at field sites to assure WFMU interface with radar modification equipment, Common Digitizer (CD), and computer software. Development of design changes was introduced to optimize the weather subsystem effectiveness. These design changes included the elimination of aircraft breakthrough by inhibiting strong aircraft returns displayed as weather contours, provision of moving target indicator (MTI)-log video to the WFMU for improvement in weather contouring when in the MTI mode, and added controls and alignment procedures for reliable WFMU performance. It was concluded that the WFMU was capable of generating reliable contours around weather clutter and was not affected by aircraft signals. Effective control of weather map data rates was accomplished by a new selectable WFMU azimuth resolution design and by a weather discrimination feature in the CD. It is recommended that the WFMU low intensity and high intensity attenuation threshold

levels be selected, to 12 and 24 dB respectively, for determining contours representative of circular polarization punch through and for establishing an area where moderate turbulence may be encountered.

NA-75-48

EVALUATION OF THE TESDATA MODEL 1155 HARDWARE MONITOR SYSTEM

Donald Fisher

Final, February 1976 19 P.

(RD-75-235) (AD A022 077)

A Tesdata model 1155 hardware monitor system was installed, tested, and evaluated at the National Aviation Facilities Experimental Center (NAFEC) to determine its ability and usefulness in performing measurement tasks on the National Airspace System (NAS) 9020 computers.

It was determined that the Tesdata model 1155 hardware monitor system meets or exceeds performance specifications and can be utilized on any of the 9020 computers without interference to the host system. Although the batch analyzer data reduction package provided with the monitor produces the reports described by the manufacturer, the amount of computer time required to perform data reduction is excessive.

NA-75-49

FEASIBILITY STUDY OF NOISE-LEVEL REDUCTIONS FOR COMPUTER DISPLAY CHANNEL EQUIPMENT USING UNDERFLOOR ENVIRONMENT AIR COOLING

John B. Garry

Final, November 1976 25 P.

(RD-76-155) (AD A033 053)

A Rocky Mountain Region Employee Suggestion, No. 9-73-4-ZDV-AF, recommended the removal of equipment cooling fans and the use of existing room air-conditioning for a noise-level reduction and as the equipment cooling medium. The under-floor cooling air was directed into the cabinets through the area occupied by the fans. The removal of the fans would result in a noise-level reduction within the room. This report evaluates feasibility studies of noise-level reduction through recovery conducted at the Boston Air Route Traffic Control Center (ARTCC). Results showed that it is possible to reduce noise levels and, in most equipment critical electronic locations, provide a reduction in operating temperature as a result of the flow of the colder underfloor air through the Computer Display Channel (CDC) equipment.

NA-75-50

EVALUATION OF TERMINAL INFORMATION PROCESSING SYSTEM CONCEPT I FOR INSTRUMENT FLIGHT RULES ROOM

Theodore Rundall

Final, February 1976 40 P.

(RD-75-184) (AD A037 198)

A method of presenting flight data on the automated radar terminal system (ARTS III) plan view display (PVD), for use in high-density terminal facilities, was evaluated. Consideration was given to the alphanumeric writing demands, the controllers' ability to read alphanumerics from various positions around the PVD, and the operational air traffic control (ATC) aspects of the concept. The method tested did not excessively burden the alphanumeric writing capability of the ARTS III. The controllers were able to read the alphanumerics satisfactorily. While the overall method of presenting data was found to be unsatisfactory, due to excessive keyboard workload and the limited number of flights on which data could be displayed simultaneously, some of the techniques employed should be retained for use in the program that succeeds Concept I.

NA-75-54

MEASUREMENT OF TOXIC GASES AND SMOKE FROM AIRCRAFT CABIN INTERIOR MATERIALS USING THE NBS SMOKE CHAMBER AND COLORIMETRIC TUBES

Constantine P. Sarkos

Final, March 1976 57 p.

(RD-76-7) (AD A023 413)

Seventy-five "self-extinguishing" materials used in wide-bodied aircraft cabin interiors were tested in the National Bureau of Standards Smoke Chamber and analyzed for smoke and toxic gases in the combustion mixture. Concentrations of selected toxic gases were measured at regular intervals during the test, either directly from the chamber or from bag samples, using colorimetric detector tubes.

Data analysis was facilitated by grouping the materials into usage designations and comparing the peak smoke and toxic gas concentrations. Despite the unknown magnitude of interference effects in the combustion mixture, detector tubes appear to offer a convenient and inexpensive method for identifying the presence of selected gases and approximating the relative gas yield of similar cabin materials.

NA-75-55

EVALUATION OF AN AIRPORT LIGHTING CONTROL AND DISPLAY SYSTEM

E. Leon Reamer

Final, October 1975 13 p.

(RD-75-158) (AD A018 035)

This report describes the techniques used and presents the result of tests that were conducted to evaluate an airport lighting control and display system to determine its suitability to control airport lighting. A mimic control and display system was developed and installed at the National Aviation Facilities Experimental Center (NAFEC). It was tested to determine its ability to: 1. expedite the operations of the air traffic controller, 2. reduce power consumption by airport regulators in the field, and 3. reduce training time. The result of the tests indicates that the mimic control and display system is very suitable for airport operations and that only economic considerations would be a determining factor in not using it. It was recommended that the system be used in any airport where multiple runways and taxiway paths exist, and also that a program be established to further determine any method that would reduce the cost of design and installation.



NA-75-56  
AIRCRAFT COMMUNICATIONS INTERFERENCE TESTS  
Jack Bernstein  
Final, March 1976 17 P.  
(AD A022 954)

This report covers tests conducted to determine the possible causes of interference to aircraft very high frequency (vhf) voice communications resulting from transmissions from the vhf digital data link system operating onboard the same aircraft.

Tests were conducted to determine aircraft vhf antenna isolation and vhf receiver response. The tests show that isolation depends on the physical positioning of the antennas on the airframe and that existing isolation (found to be as little as 23 dB) can realistically cause interference or quieting between transceivers even though they are operating at different frequencies up to 4 MHz apart. It was also found that transceiver design affects the rejection of undesired received signals.

It was recommended that maximum isolation be maintained between aircraft antennas, receiver design be optimized for rejection of undesired signals, and cockpit communications discipline be used.

NA-75-57  
IMPROVEMENT TO DOPPLER VOR SIDEBAND ANTENNA MONITOR, TYPE FA-8142  
James G. Dong  
Final, February 1976 32 P.  
(RD-76-4) (AD A022 953)

An investigation was accomplished on a Doppler very high frequency omnidirectional radio range (DVOR) Sideband Antenna Monitor to determine methods of eliminating the possibly unreliable operation when an antenna fault occurs. Minor modifications were made in the monitor to improve adjustment. Tests were accomplished in the Doppler No. 2 site at the National Aviation Facilities Experimental Center (NAFEC). Included in the investigation was the operation of the monitor with a slotted cylinder antenna. The test results indicate that the most reliable monitor operation was obtained with the modified monitor using a slotted-cylinder antenna coaxially located above the carrier antenna.

NA-75-58  
FLIGHT TEST OF A SELF-GENERATING OVERHEAT DETECTION SYSTEM  
Richard G. Hill  
Final, January 1976 21 P.  
(AFAPL-TR-76-1) (AD A031 591)

Flight tests were conducted on two self-generating overheat detection systems installed in the number two nacelle of a Federal Aviation Administration (FAA) Convair CV880. The systems were mounted inboard and outboard in the nacelle paralleling the existing aircraft system. The outboard system logged 722.2 flight



hours with no problems reported. The inboard system logged 615.0 flight hours. Shortly after the inboard system was installed, overheat warnings were obtained when the thrust reversers were used.

NA-75-59

STAGGER/DESTAGGER MODIFICATIONS FOR THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM

Paul Todd and Nicholas Talotta

Final, January 1976 50 P.

(RD-75-193) (AD A021 835)

The air traffic control radar beacon system (ATCRBS) was modified so as to eliminate false or second-time-around aircraft replies. A dual-channel stand-alone modification equipment unit was developed to stagger the beacon interrogations and destagger the reply video. The unit can be used with any beacon interrogator defruiter or processor. Two models, an analog and a digital, were developed. The resulting equipments were implemented and tested at the Bedford, Virginia, long-range radar facility.

During the engineering tests and operational evaluation, the stagger modification performed reliably. It is recommended that the digital version be implemented at the field facilities.

NA-75-60

EFFECTIVENESS OF A PILOT GROUND TRAINER AS A PART TASK INSTRUMENT FLIGHT RULES FLIGHT-CHECKING DEVICE STAGE II

Robert J. Ontiveros

Final, June 1976 66 P.

(RD-76-72) (AD A026 754)

The second stage of a two-stage experiment was conducted at the National Aviation Facilities Experimental Center (NAFEC) to determine if a pilot ground trainer (PGT) could be used to flight check instrument-pilot applicants on instrument approaches in lieu of performing these tasks in an aircraft on their initial instrument flight check. Stage I defined the capabilities and equipment of PGT's considered essential for training pilots to perform instrument approaches and related instrument procedures. Based on the comparative PGT and aircraft performance scores of a control and experimental group, the results of Stage II indicate that an appropriately equipped PGT may be used to flight check instrument-pilot applicants on the automatic direction finder (ADF) very high frequency omnidirectional radio range (VOR), and instrument landing system (ILS) approaches. The report lists the equipment and capabilities required for the ground trainer to be effective as a part-task flight-checking device for accomplishing these tasks. Significant differences between PGT and aircraft performance scores are discussed. Factors contributing to the performance differences are identified.

NA-75-61

TEST AND EVALUATION OF THE DALLAS/FORT WORTH TERMINAL COMMUNICATIONS SWITCHING SYSTEM

Richard W. Cleary, Anthony Spingola, Stephen Karovic and P. E. Hinely  
Final, November 1976 80 P.  
(RD-76-111) (AD A040 665)

This report details the operational and technical evaluation of the air traffic control (ATC) terminal communications switching system (TCSS) at the Dallas/Fort Worth Tower/TRACON (Terminal Radar Approach Control) facility by personnel from the National Aviation Facilities Experimental Center. The system was designed and built for the Federal Aviation Administration and is innovative in that it uses frequency division multiplexing techniques for ATC instead of conventional communication-channel separation methods. The following are other TRACON communication innovations: communications are carried over a single coaxial cable in the 10-MHz to 15-MHz band; solid state logic circuitry is used for electronic switching of voice and radio-remoting interconnections; positional communications reconfiguration is under processor control; and all direct access keys and radio-select keys use light-emitting diodes for designators. In addition to a technical evaluation of equipment performance, an evaluation of the ATC operational performance of the TCSS was conducted using facility personnel as test subjects. Responses on questionnaires completed by the test subjects indicated that, with minor exceptions, the system satisfies requirements. Learning to operate a system position requires a minimal amount of training, and the system has the capabilities of growth and flexibility.

NA-75-62

AN INVESTIGATION INTO THE CAPABILITY OF MONITORING THE NADIF ANTENNA

Nicholas J. Talotta and Donald E. Rogers  
Final, June 1976 45 P.  
(RD-76-96) (AD A026 889)

A requirement exists to develop a monitoring capability for air traffic control radar beacon system (ATCRBS) ground station equipments. The National Aviation Facilities Experimental Center (NAFEC) has conducted tests of the NAFEC dipole-feed beacon antenna (NADIF antenna) to determine if it can be monitored in the electrical near field of the antenna. Comparison-type data were obtained in the electrical near and far field of the antenna. The data indicate that the antenna can be monitored in the near field on the standard antenna tower, providing the monitor pickup probe is carefully positioned.

NA-75-63

PERFORMANCE AND FLIGHT TESTS OF THE TYPE I FLIGHT INSPECTION MONITOR (FIM-I)

Nicholas J. Talotta, and Paul Todd  
Interim, May 1976 27 P.  
(RD-76-56) (AD A026 080)

Performance tests were conducted by the National Aviation Facilities Experimental Center (NAFEC) on the air traffic control radar beacon system (ATCRBS) type I flight inspection monitor (FIM-I). The FIM-I equipment was then installed on a

NAFEC test aircraft for limited flight testing in the mid-Atlantic states. Software was developed for data reduction and postflight analysis to evaluate the performance of the FIM-I equipment. Laboratory performance tests showed that the equipment met contract specifications. Flight test data showed a deficiency in performance on signals near minimum trigger level sensitivity, but since these were a small percentage of the total data, the interrogation environmental information obtained was eminently useful and informative. It is concluded that the equipment performance deficiency should be corrected and that additional data analysis software is required prior to effective utilization of FIM-I for ATRCBS monitoring.

NA-75-64

AIR TRAFFIC CONTROL EXPERIMENTATION AND EVALUATION WITH THE NASA ATS-6,  
SATELLITE--VOLUME II: DEMONSTRATION OF SATELLITE-SUPPORTED COMMUNICATIONS  
AND SURVEILLANCE FOR OCEANIC AIR TRAFFIC CONTROL

Francis W. Jefferson

Final, April 1976 96 P.

(RD-75-173-II) (AD A042 146)

Demonstrations of satellite-supported communications for application to oceanic air traffic control (ATC) were conducted as part of an international ATS-6 L-band satellite test program. The ATC demonstrations were comprised of two phases: demonstrations conducted solely for United States (U.S.) Department of Transportation Federal Aviation Administration purposes and demonstrations conducted as a joint effort between U.S., European Space Agency (ESA), and Canada.

Voice, data and dependent surveillance communications between air traffic controllers at a ground terminal and pseudopilots in two airborne aircraft, FAA KC135 and ESA COMET IV, were performed via the ATS-6 satellite and Rosman ground station. A simulated aircraft terminal located at Rosman was also employed. Each terminal provided up to six simulated data link aircraft, through computer software, for traffic loading purposes. Canada provided a voice-only simulated aircraft terminal located in Ottawa. Voice and data scenarios were used to create simulated air traffic. Results were: Dependent ATC surveillance was demonstrated through data link automatic aircraft position reports; position data were obtained from an inertial navigation system in the KC135 and an Omega navigation system in the COMET; and to a limited extent, independent surveillance was demonstrated using the NASA PLACE system and the ATS-6 and ATS-5 satellites.

NA-75-66

A SUMMARY OF RUNWAY FRICTION CHANGES DUE TO HIGH-PRESSURE WATER-JET CLEANING OPERATIONS AT FOUR AIRPORTS

Charles Grisel

Final, January 1976 17 P.

(RD-75-218) (AD A021 684)

The subject effort evaluated a new method of removing rubber from concrete runways in terms of its effect on runway surface friction. This rubber removal method consisted of jetting water at high velocities to remove the rubber deposits from the surface. The results of the tests indicate that commercial equipment and procedures can be used to remove all the above-the-surface rubber deposits, do not visibly damage the surface, and increase wet runway surface friction in the rubber-laden aircraft touchdown areas.

NA-75-67

TEST AND EVALUATION OF SIX WIRE-WOUND TACTICAL AIR NAVIGATION AID (TACAN) HEATED RADOMES WITH WEATHER SENSORS

Harold Postel

Interim, August 1976 50 P.

(RD-76-130) (AD A030 336)

This report covers the field evaluation of six wire-wound tactical air navigation aid (TACAN) heated radomes and weather-sensing systems from October 1974 through April 1975 installed on very high frequency omnirange/TACAN station's (VORTAC's) at (1) Mullan Pass, Idaho, (2) Lakeview, Oregon, (3) Elko, Nevada, (4) Denver, Colorado, (5) Rochester, Minnesota, and (6) Clarion, Pennsylvania. The purpose was to evaluate these six prototype TACAN radomes, with embedded wire-wound heaters, to determine their effectiveness in preventing weather effects due to snow and/or ice accumulation at these six selected VORTAC facilities. Analysis of the data which were collected during the 6 months of testing indicates that the wire-wound radome, when modified with improved control stabilization circuit and adjusted for optimum operation, was effective in minimizing the accumulation of ice and/or snow on the vertical surface of the radome. Several modifications were developed by site personnel to reduce or prevent excessive hunting by the various control circuitry. Further test and evaluation should be performed during the next winter to determine the most effective approach before any recommendation for field implementation.

NA-75-68

TESTS WITH WILCOX SLOTTED-CYLINDER VOR ANTENNA

Wayne E. Bell and Edward N. Lind

Final, April 1976 44 P.

(RD-76-30) (AD A026 391)

An improved Wilcox slotted-cylinder VOR antenna was evaluated when configured for VOR, VOR/DME, and VORTAC operations. Airborne and ground measurements which included bearing error, vertical polarization, and "cone of confusion" tests determined that the antenna meets Federal Aviation Administration operating tolerances.

NA-75-69

AN ANNOTATED COMPILATION OF NAFEC VISUAL AID LETTER AND DATA REPORTS 1971 - 1975  
E. Leon Reamer  
Final, May 1976 69 P.  
(RD-76-74) (AD A025 237)

This report releases Federal Aviation Administration (FAA) letter and data reports to the general public. These reports were issued by the National Aviation Facilities Experimental Center (NAFEC) to the System Research and Development Service (SRDS) between the years 1971 to 1975, and cover testing and evaluation efforts for visual guidance and airport lighting configurations.

Contained herein are the original letter and data reports including an annotation of the results and actions brought about by their findings.

NA-75-70

TEST AND EVALUATION OF BROADBAND VHF ISOLATOR  
James J. Coyle  
Interim, May 1976 12 P.  
(RD-76-67) (AD A024 477)

This report describes a prototype broadband VHF ferrite isolator device that can be used to reduce transmitter intermodulation in air traffic control air/ground communication equipments. The isolator was developed for the Systems Research and Development Service through an Inter-Agency Agreement with the United States Air Force. The isolator was tested at the National Aviation Facilities Experimental Center and was found to reduce T-1108/GRT-21 transmitter intermodulation approximately 30 dB. Test results fell short of design goals for weight, insertion loss, and intermodulation product reduction.

NA-75-71

A FLIGHT INVESTIGATION OF SYSTEM ACCURACIES AND OPERATIONAL CAPABILITIES OF AN AIR TRANSPORT AREA NAVIGATION SYSTEM  
Robert H. Pursel and Jack D. Edmonds  
Final, May 1976 99 P.  
(RD-76-32) (AD A025 139)

Flight tests were conducted at the National Aviation Facilities Experimental Center (NAFEC) using an Aeronautical Radio Incorporated (ARINC) Characteristic 582-4, "Mark 2 Air Transport Area Navigation System" to investigate area navigation (RNAV) system accuracies and resultant airspace requirements with emphasis being given to the terminal area. The system was operated in various navigational configurations including dual very high frequency omni-directional radio range/distance measuring equipment (VOR/DME), single VOR/DME, and dual DME. Statistical data are presented for the various error components making up the RNAV total system error. Various operational capabilities were also investigated and graphical data are presented for parallel offsets, paralleling in turns, and turn anticipation. The most accurate modes were dual DME and dual VOR/DME with single VOR/DME being the least accurate. The feasibility of a Flight Technical Error (FTE) of less than  $\pm 1.0$  nmi in the terminal area was also demonstrated.

NA-75-73

TEST AND EVALUATION OF ATCRBS ELECTRONIC SCAN ANTENNA (SYSTEM TEST)

Anthony D. Bradley

Final, August 1976 59 P.

(RD-76-97) (AD A029 486)

The air traffic control radar beacon system (ATCRBS) experimental electronic scan antenna (ESA) consists of 56 array modules placed on a platform (ring) constructed around the top of an airport surveillance radar tower. A shelter beneath the tower provides an enclosure for the control and radiofrequency distribution system of the ESA. This final report covers the system testing to demonstrate the ATCRBS ESA dynamic capabilities in typical terminal environment and to examine beacon monopulse performance. It is concluded that the computer-controlled ATCRBS ESA demonstrated the automated features of the antenna, including agile beam management. In addition, the ATCRBS ESA monopulse target detection system was exercised during the flight test effort. This testing established that the field environment and aircraft maneuvering affected the resulting parameters of system operation (i.e., azimuth accuracy and received signal level). Basic monopulse target detection and processing is feasible for the ATCRBS.

NA-75-150

ELECTROMAGNETIC INTERFERENCE SPECIFICATION LIMITS FOR AIR ROUTE TRAFFIC CONTROL CENTERS

Margaretta V. Stone

Final, March 1975 112 P.

(RD-75-29) (AD A008 926)

This report consists of a specification, covering the test limits for measurement of electromagnetic interference (EMI) characteristics of electronic equipment, intended to be installed in Air Route Traffic Control Centers (ARTCC's) by the Federal Aviation Administration (FAA). Limits and requirements for both emission and susceptibility are included.

The limits are based on an analysis of radiated and conducted emission levels, found during EMI tests performed at three ARTCC's.

The specification also contains guidance for selection of specific limits for various ARTCC areas, and outlines of suggested procedures for performing tests. These procedures are based on those contained in MIL-STD-462.

NA-75-151

FLIGHT TEST INVESTIGATION OF THE VORTEX WAKE CHARACTERISTICS BEHIND A BOEING 727 DURING TWO-SEGMENT AND NORMAL ILS APPROACHES

M. R. Barber, R. L. Kurkowski, L. J. Garodz, G. H. Robinson, H. J. Smith, R. A. Jacobsen, G. S. Stinnett, Jr., T. C. McMurtry, J. J. Tymczyszyn, R. L. Devereaux, A. J. Bolster

Technical Memorandum 138 P

(A-5815) (AD A018 366)

A series of flight tests were performed to evaluate the vortex wake character-

istics of a Boeing 727 (B727-200) aircraft during conventional and two-segment ILS approaches. Twelve flights of the B727, equipped with smoke generators for vortex marking, were flown wherein its vortex wake was intentionally encountered by a Lear Jet model 23 (LR-23) of a Piper Twin Comanche (PA-30); and its vortex location during landing approach was measured using a system of photo-theodolites.

The tests showed that at a given separation distance there were no readily apparent differences in the upsets resulting from deliberate vortex encounters during the two types of approaches. Timed mappings of the position of the landing configuration vortices showed that they tended to descend approximately 91 meters (300 feet) below the flight path of the B727. The flaps of the B727 have a dominant effect on the character of the trailed wake vortex. The clean wing produces a strong, concentrated vortex. As the flaps are lowered, the vortex system becomes more diffuse. Pilot opinion and roll acceleration data indicate that 4.5 nautical miles would be a minimum separation distance at which roll control could be maintained during parallel encounters of the B727's landing configuration determined from previous tests of other aircraft using the same roll control criteria.

NA-75-152

THE USE OF DYNAMIC SEARCH AREAS IN THE NATIONAL AIRSPACE SYSTEM ENROUTE COMPUTER PROGRAM

Francis R. Mullin

Final, May 1975 20 P.

(RD-75-77) (AD A012 496)

The use of "online computed" search areas in the National Airspace System (NAS) enroute tracking algorithm is investigated in this report. The search areas currently used in the enroute model 3d2 computer program are of fixed values, and cannot provide turn detection precise enough to make use of the track-oriented smoothing feature of the NAS bimodal tracker. The results indicate that the dynamic search areas provide superior performance to the method currently specified.

NA-75-153

IGNITION AND PROPAGATION RATES FOR FLAMES IN A FUEL MIST

C. E. Polymeropoulos

Interim, April 1975 61 P.

(RD-75-155) (AD A017 786)

A mathematical model was developed, which is capable of predicting the burning velocity in polydisperse air-fuel sprays given the initial conditions of the liquid and gas phases. The analytical predictions were tested against previous experimental data, and the agreement was satisfactory.

The burning velocity in polydisperse kerosene-air sprays was measured at constant air-fuel ratio, and for various degrees of atomization of the spray in order to further check the predictions of the mathematical model. The results were also in good agreement with the analytical predictions.

NA-75-155

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY BALTIMORE TOWER/TRACON  
PITTSBURGH TOWER/TRACON

Don Martin

April 1975

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NA-75-158

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY O'HARE TOWER/TRACON

J. Hartnett

June 1975

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NA-75-159 (See NA-75-155)

NA-75-160

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY ATLANTA TOWER/TRACON

J. Hartnett

June 1975

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NA-75-161

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY ST. LOUIS TOWER/TRACON

J. Hartnett

June 1975

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NA-75-164

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY TAMPA INTERNATIONAL AIRPORT (TOWER/TRACON)

J. Maurer

June 1975

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NA-75-165

McCLELLAN RAPCON SACRAMENTO, CALIF.

F. Hierbaum

October 1975

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NA-75-166

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY HOUSTON INTERCONTINENTAL AIRPORT (TOWER/TRACON)

J. Maurer

June 1975

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NA-75-167

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY NEW ORLEANS INTERNATIONAL AIRPORT (MOISANT FIELD) (TOWER/TRACON)

J. Maurer

June 1975

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NA-75-169

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY KANSAS CITY INTERNATIONAL  
TOWER/TRACON

J. Hartnett

June 1975

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NA-75-170

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY BOSTON TOWER/TRACON

D. Martin

July 1975

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NA-75-171

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY JACKSONVILLE TOWER/TRACON

D. Martin

August 1975

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NA-75-172

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY MIAMI INTERNATIONAL TRACON/  
TOWER

D. Martin

August 1975

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NA-75-174

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY MINNEAPOLIS-ST PAUL  
INTERNATIONAL AIRPORT TOWER/TRACON

R. Miller

September 1975

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NA-75-175

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY WASHINGTON TOWER/TRACON

W. Donaghy

September 1975

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NA-75-176

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY DETROIT METRO AIRPORT

TOWER/TRACON

R. Miller

September 1975

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NA-75-177

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY SAN DIEGO INTERNATIONAL AIRPORT  
- LINDBERGH TOWER SAN DIEGO APPROACH CONTROL - NAS MIRAMAR

F. Willet Jr.

September 1975

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series

of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-75-178

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY LOS ANGELES

TOWER/TRACON

P. J. O'Brien

November 1975

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-75-179

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY ORANGE COUNTY TOWER COAST TRACON (MCAS EL TORO)

F. Willett Jr.

October 1975

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NA-75-180

APPLICATIONS OF THE SIMULATION MODEL FOR AIR TRAFFIC CONTROL COMMUNICATIONS

J. S. Hunter and D. A. Hsu

Interim, February 1977 254 P.

(RD-76-19)

This report contains a review of the GPSS simulation program for air traffic control (ATC) communications, its structure, validation, and applications. The model, constructed using ATC communications data from the New York Center, was checked against ATC communications data from Houston with excellent results. Studies of the applications of the model are described with respect to communications capacity and queuing, the effects of reducing the number of transmissions per transaction, the effects of tone-bursts of different duration, the sensitivity of communication responses to changes in various input variables, etc. The construction of general simulations for sector types, as opposed to individual sectors, is described. (This work may be of special significance to the simulations of oceanic communications performance.) The problems, and some of the progress, in combining sector functions into networks analogous to a communications center are discussed. The multi-dimensional aspects of sector communications are simplified through the construction of new indices. Queuing time analyses and forecasting for ATC communications are reported.

NA-75-184

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY SAN JUAN TOWER/TRACON

D. Martin

October 1975

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-75-185

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY HONOLULU TOWER/TRACON

J. R. Bradley

November 1975

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NA-75-187

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY PHILADELPHIA TOWER/TRACON  
W. Donaghy  
December 1975

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NA-75-188

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY LAS VEGAS TOWER/TRACON  
R. Miller  
January 1976

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NA-75-189

GROUND/AIRBORNE SCENARIOS J. F. KENNEDY AND LAGUARDIA INTERNATIONAL AIRPORTS  
Lt. Col. J. D. Hartnett  
January 1976

NA-75-190

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY PHOENIX TRACON PHOENIX SKY  
HARBOR TOWER

R. Miller

January 1976

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-75-191

GROUND/AIRBORNE SCENARIOS STAPLETON INTERNATIONAL AIRPORT

Lt. Col. John D. Hartnett

February 1976

NA-75-193

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY CLEVELAND TOWER/TRACON

D. Martin

December 1975

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-76-2

INDEPENDENT ALTITUDE MONITOR: A LITERATURE SEARCH, ANALYSIS, AND BIBLIOGRAPHY

Jack J. Shrager

Final, August 1976 50 P.

(RD-76-127) (AD A029 541)

A literature search of recent activity to provide an independent indication of aircraft altitude was undertaken. Results indicate that there are several existing techniques in use which can readily be expanded to enhance altitude awareness to avoid inadvertent terrain collisions. Also identified are other new potential candidate systems concepts.

NA-76-3

PLAN VIEW DISPLAY (PVD) BACKGROUND LIGHTING

Philip C. Gustafson, John Aschenbach, and Richard L. Sulzer

Final, May 1976 50 P.

(RD-76-46) (AD A024 954)

Controllers at air route traffic control centers (ARTCC's) have complained that display information on plan view displays (PVD's) causes eyestrain and headaches after a prolonged period of controlling traffic. The controllers indicated that background brightness level similar to the type previously experienced for raster-scanned displays might be a remedy. Therefore, an investigation and evaluation of several methods of generating a uniform background brightness on the PVD were conducted. Results show that the defocused raster method is the most effective and practical type of background brightness generation to be considered for field evaluation. The etched-surface cathode-ray tube also tended to produce a more uniform background illumination than most techniques investigated.

This report is a survey of several methods to generate a uniform background brightness on the face of a plan view display (PVD) in an air route traffic control center (ARTCC). The background brightness is intended to offset the undesirable PVD characteristics of high contrast and front surface reflections, which is annoying to the vision of the air traffic controllers.

NA-76-5

EVALUATION OF IMPROVED RUNWAY EDGE LIGHTS

Raymond E. Johnston

Final, June 1976 25 P.

(RD-76-101)

The purpose of this activity was to evaluate a newly designed runway edge light fixture using a 100-watt lamp as its light source, rather than the standard 200-watt lamp, to determine if a lower wattage lamp would satisfy category I and category II low-visibility operations.

Laboratory and actual low-visibility flight tests were conducted on the new fixtures. The results of the laboratory tests show that this fixture with the 100-watt lamp nearly meets the requirements of FAA Specification L-862. By minor changes in the optics, lights suitable for type L-862 requirements may be obtained.

Results of the flight tests indicated that the 100-watt lamp was adequate for category I weather operations, and it was felt that the system would support category II operations, as the light output appeared well balanced with the other runway light systems.

This report is the final report of a series that includes interim reports, FAA-RD-74-128, "Evaluation of an Experimental Elevated High-Intensity Runway Edge Light," and FAA-RD-74-171, "Evaluation of an Experimental High-Intensity, Inset Runway Edge Light Fixture."

NA-76-6

AIRSPACE CONFIGURATION AND SEPARATION EVALUATION--CONFIGURATION AND PROCEDURES---  
TERMINAL ATC DIGITAL DISPLAY SYSTEM ERRORS, ARTS III

Harry T. Morgan, Jr. and Arthur R. Moss

Final, November 1976 166 P.

The major position and separation errors associated with the digital data provided to the radar controller by the Automated Radar Terminal System (ARTS III) are quantitatively assessed to provide the basis for specifying the air traffic control separation minima in ARTS-controlled airspace. The National Aviation Facilities Experimental Center provides a Terminal Automation test Facility at the Atlantic City Airport with a full complement of technical support facilities and engineering staff; here, an extensive series of live and simulated flight tests were conducted. The methodology, results, and conclusions of this effort are discussed. The results indicate that 99.9 percent of the overall range and azimuth errors can be expected to fall within  $\pm 0.16$  nmi and  $\pm 1.43^\circ$ , respectively about their mean errors with a confidence of 90 percent. These errors are less than those generated in trying to read position from the radar displays.

The ARTS III Radar Beacon Tracking Level system reported on herein utilized existing prototype hardware and software as available in early 1974. Many of the capabilities described in this report have since been enhanced by a continuing development program. The reader is encouraged to inquire into the availability of any later reports pertinent to this system.

NA-76-8

TEST AND EVALUATION OF A PROTOTYPE VERY HIGH FREQUENCY LOW-INTERMODULATION  
AMPLIFIER

James J. Coyle

Interim, September 1976 12 P.

(RD-76-119) (AD A029 848)

This report describes the test and evaluation of a prototype very high frequency (VHF) low-intermodulation amplifier that was designed as a frequency-independent interference rejection circuit for the T-1108/GRT-21 air/ground communication transmitter. The amplifier was developed for the Federal Aviation Administration through an interagency agreement with the United States Air Force. The amplifier was tested in the Experimental Peripheral Communications Laboratory at the National Aviation Facilities Experimental Center. Test results showed the amplifier could reduce T-1108/GRT-21 transmitter third-order intermodulation products at least 48 dB when aligned for a single interfering frequency condition, but the amplifier did not achieve the desired 15-dB intermodulation reduction when aligned for broadband interference cancellation across the 118-136 MHz VHF air/ground communication frequency band.

NA-76-10

PHOTOGRAPHIC INVESTIGATION OF MODIFIED FUEL BREAKUP AND IGNITION

Samuel V. Zinn, Thor I. Eklund and William E. Neese

Final, September 1976 32 P.

(RD-76-109) (AD A030 053)

Laboratory evaluations were performed to determine the flammability characteristics, physical properties, and rheological profiles of modified fuel sprays. Photographs were made of fuel particles formed by air shearing in the NAFEC Fire Test Facility. Ignition studies of the modified fuel sprays included photographs of typical combustion patterns. Comparisons of shear viscosity, droplet geometries, and ignitability of the different antimisting fuels clarify the effect of polymeric additives on turbine fuel safety, and indicate critical criteria for modified fuel specifications.

The results of this investigation lead to two major conclusions. First, the modified fuel spray consists of particles of large size and highly aspherical geometry. Second, although a modified fuel can be flammable in the presence of an intense ignition source, all modified fuels tested were more difficult to ignite than neat fuel.

NA-76-11

OPERATIONAL AND TECHNICAL ANALYSIS GTE/WESCOM KEY/AUTOMATIC CALL DISTRIBUTOR COMMUNICATION SYSTEM, PORTLAND, OREGON, FLIGHT SERVICE STATION

Richard K. Ohman and Edward M. Sawtelle

Final, November 1976 130 P.

(RD-76-148) (AD A033 052)

Field test and evaluation of the Portland, Oregon, Flight Service Station (FSS) GTE/WESCOM Key/Automatic Call Distributor Communication System (ACD) were accomplished to determine the applicability of the equipment as a system to be specified for high-activity FSS's.

The system test and evaluation were accomplished by (1) evaluation of normal facility operation, (2) conduct of scripted tests, (3) analysis of FSS specialist's responses to questionnaires, and (4) analysis of operational failure logs and equipment design.

Onsite observation of frequent circuit failure attributable to either system logic error, fabrication error, or integrated circuit chip failure led to the conclusion that the system did not function reliably and that such integrated circuit ACD systems should be given standard engineering and operational tests in a laboratory environment.

Performance of the Common Control Subsystem, as limited to the Portland FSS, generally evidenced the requisite degree of utility and service efficiency. The ACD function from the date of installation did not measure up to Preflight specialist or calling party requisites. The ACD function, on occasion, did evidence equal distribution of inbound calls to the in-service Preflight posi-

tions. The general application of the candidate WESCOM ACD is not recommended for high-activity FSS facilities.

NA-76-12

AIRCRAFT CABIN COMPARTMENTATION CONCEPTS FOR IMPROVING POSTCRASH FIRE SAFETY  
Richard Hill, Paul N. Boris, and George R. Johnson  
Final, October 1976 74 P.  
(RD-76-131) (AD A033 051)

Aircraft cabin compartmentation was investigated as a means of increasing escape time for passengers during a postcrash cabin fire. The size and configuration of various partitions and/or curtains were investigated to determine their effectiveness in providing protection from a cabin fire by limiting the spread of heat, smoke, carbon monoxide (CO), and the depletion of oxygen from the vicinity of the fire to other areas of the cabin. The results of these tests indicated that a tightly sealed partition and/or curtain afforded the greatest protection from the spread of a given amount of heat, smoke, CO, and depletion of oxygen. The results also indicated that the use of compartmentation can adversely affect the intensity of a fire in an unclosed area, creating more products of combustion. Except for a limited number of cases, the amount of protection provided by the partition exceeded the increase in fire intensity.

NA-76-13

AN EVALUATION OF WINDOW GLASS FOR AIR TRAFFIC CONTROL TOWER CABS  
Lee Paul, J. Roy Bradley, and Donald A. Martin  
Final, October 1976 42 P.  
(RD-76-105) (AD A031 924)

Seven samples of commercially available glass were evaluated to determine their suitability for use in air traffic control tower cabs. Spectral transmissivity measurements were made on each sample for all wavelengths in the visible spectrum. A small experimental tower cab was constructed near the NAFEC airport, and controllers evaluated the samples in the tower cab under day, night, dawn, and dusk viewing conditions. The controller ratings were analyzed and evaluated in terms of the optical transmissivity of the samples and the type of window; i.e., single pane and double pane. There were differences in the ratings of the samples, and the relative merit of the samples depended, in part, on the time of day the ratings were made. An unexpected factor in the ratings was the appearance of internal reflections in the double pane windows at night.

NA-76-14

ATC/AIRBORNE CAS COMPATIBILITY - AN ANALYSIS OF FIELD-DERIVED DATA

Gordon Jolitz

Final, June 1976 70 P.

(RD-75-228) (AD A026 070)

Two realtime simulation experiments were conducted at the National Aviation Facilities Experimental Center (NAFEC) for the purpose of investigating the interface between the Air Traffic Control (ATC) system and a proposed Airborne Collision Avoidance System (ACAS). Based on results of those experiments, it was concluded that: (1) Some means of desensitizing the ACAS in the final approach sequencing and spacing zone of busy terminal areas was mandatory, and (2) The concentration of ATC/ACAS interaction would probably vary from site to site. In lieu of further realtime simulation, track history data were recovered from the Washington, Chicago, Los Angeles, and Miami ARTS III facilities. After intermediate processing, the digital representation of the traffic flows were inspected by a software model of the ACAS. Results were reduced in the form of alarm rates, before and after desensitization. Results of the analysis confirmed the conclusion that some form of desensitization would be required. It was further concluded that desensitization procedures would not only vary from site to site, but would also be dependent on the runway utilization configuration at a given site. A secondary objective of this activity was the development of methodology and software for recovering and reprocessing real world air traffic data such that the end product was a field-derived data bank containing forty-eight 1-hour samples of high density terminal area traffic--12 from each of the locations previously noted.

NA-76-15

EXTENDED STORAGE FEATURE MODIFICATIONS TO THE 9020A SYSTEM

Donald A. Fisher, Lane G. Hinkley, and Charles R. Shaw

Final, June 1976 52 P.

(RD-76-89) (AD A027 281)

In order to meet the future demands of the Air Traffic Control Upgraded Third Generation System, hardware/software architectural design changes were developed to provide additional core storage and processing capability. These changes, known as the Extended Storage Feature, were implemented in the 9020A System. This report discusses the hardware/software modifications, acceptance tests, and cost considerations involved in implementing this feature.

It was concluded that the Extended Storage Feature can be implemented at the 10 enroute ATC 9020A System sites for a total cost of \$1,633,000, including all hardware and software modifications required to equip each site with two 7251-08A Storage Elements. Implementation of the Extended Storage Feature will increase the storage capacity of a 9020A System by 64K words per storage element converted without requiring additional floor space and can be installed without impacting operational activity.

NA-76-16

AMBIENT TEMPERATURE AND HUMIDITY CORRECTION FACTORS FOR EXHAUST EMISSIONS FROM  
TWO CLASSES OF AIRCRAFT TURBINE ENGINES

Louis Allen and Gerald R. Slusher

Final, October 1976 94 P.

(RD-76-149) (AD A031 923)

Correction coefficients to reduce the production of exhaust emissions to standard-day conditions for ambient temperature and humidity were developed for two classes of aircraft turbine engines. Correlation and multiple regression methods were utilized in the analysis of emission measurements recorded from two turbine engines, operated under naturally occurring environmental conditions, starting in the winter and continuing through the summer season. Correction factors were established for the emission index (EI) and power index (PI) for carbon monoxide (CO), total hydrocarbons (THC), and nitrogen oxides (NO<sub>x</sub>) for each of five engine power conditions of idle, approach, cruise, maximum continuous, and takeoff. Ambient temperature produced the dominant effect on all gaseous emissions. EI and PI for THC required the greatest magnitude of ambient temperature correction factors. Humidity had a significant secondary effect on the generation of NO<sub>x</sub>. The effects of barometric pressure were within experimental error for the minimal range of pressures encountered. The correction coefficients established from a TF30-P1 engine data base were determined to be applicable for correction of JT8D engine emissions. The temperature and humidity effects on the generation of emissions are now considered to have been a major source of variability of measurements from past investigations.

NA-76-18

PLAN VIEW DISPLAY (PVD) IMPROVEMENT PROGRAM, COUNTERBALANCE SYSTEMS

H. Fred Schneider

Interim, December 1976 64 P.

(RD-76-173)

The factors which led to the Plan View Display (PVD) conversion problems at the 20 Air Route Traffic Control Centers (ARTCC) in the United States were investigated through life tests and studies. Recommendations were made for appropriate changes to the PVD conversion counterbalance system, and were forwarded to the contracting officer's technical representative (COTR) to provide an interim solution to this problem in the field. An alternate counterbalance system was developed and designed to provide a better solution. These systems are presently being fabricated and will be subjected to study and life testing in time to provide full data and recommendations scheduled for inclusion in the final report on this project.



NA-76-19

DESIGN AND EVALUATION OF VISIBILITY SENSOR/RUNWAY VISUAL RANGE COMPUTER INTERFACE CIRCUITRY

James E. Newcomb

Final, January 1978 35 P.

(RD-77-86)

Runway visual range (RVR) is an aviation visibility value obtained by utilizing a special purpose signal data converter. Atmospheric transmittance, one of the processing parameters used, is provided by a National Bureau of Standards type transmissometer that samples clarity of the atmosphere by measuring the amount of incandescent light from a known source remaining in the beam after passing through a baseline distance of 500 or 250 feet. New types of visibility sensors are now being produced that operate on a light-scattering principle rather than attenuation. These new types of sensors are being considered as alternatives to the NBS transmissometer. If found suitable, these new sensors will require signal conditioning circuitry in order to operate in conjunction with existing, standard-type RVR computers. This report describes the design and testing of such an interface circuit to permit use of the EG&G model 207 Forward Scatter Meter (FSM) with the RVR computer. The output of the FSM is an 0 - 5 V d.c. analog voltage proportional to the scattering coefficient. This circuit design changes the analog voltage to a pulse train with pulse rate, width, and amplitude comparable to the standard transmissometer output. Circuit design was validated by system tests. The new design produced computer-displayed RVR values equivalent to those normally provided by an NBS transmissometer. It was concluded that the circuit design does provide accurate interface between the EG&G model 207 FSM and FA-7871-type signal data converters.

NA-76-20

TEST AND EVALUATION OF A FEASIBILITY MODEL ILS GLIDE SLOPE PERFORMANCE ASSURANCE MONITOR FOR THE FINAL APPROACH PATH

Marvin S. Plotka

Final, December 1976 106 P.

(RD-76-176) (AD A034 892)

The second of two test and evaluations was performed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, to determine the feasibility of a ground-based monitoring system to accurately measure the flightpath of selected aircraft on the final approach path. This tracking information would provide a data base for statistical analysis of the instrument landing system (ILS) glide slope performance. This subsystem was tested by comparison of its measured glide slope angle with the glide slope angle generated by the NAFEC phototheodolite tracking system (time referenced). The data analysis indicates this glide slope monitor feasibility model was not adequate to perform as an ILS performance assurance monitor. The other test and evaluation is reported in FAA-RD-74-66, dated April 1974.

NA-76-21

EVALUATION OF A HALON 1301 SYSTEM FOR POSTCRASH AIRCRAFT INTERNAL CABIN PROTECTION

Richard Hill and Paul N. Boris

Final, October 1976 35 P.

(RD-76-132) AD A032 150)

The use of a Halon 1301 fire-suppression system was evaluated in regard to increasing escape time during a ground crash situation with an internal cabin fire. Tests were conducted in a DC7 fuselage varying the exit configurations, and fire size at agent discharge. Smoke, temperature, carbon monoxide, oxygen, and Halon 1301 levels were continuously monitored during the tests at various locations throughout the cabin. A sampling system for collecting hydrogen fluoride (HF), Halon 1301's primary decomposition product, was used. Samples at four locations were taken every 30 seconds, for 5 minutes after discharge. The use of a curtain to inhibit the spread of HF was also examined.

The results indicated that in order to minimize the HF concentrations, the fire should be extinguished when its size is as small as possible, and prior to the opening of cabin exits. In order to reduce HF concentrations, the cabin exits should be opened as soon as the fire is extinguished. The use of a curtain to partition the cabin greatly reduced the spread of HF from the fire zone to the protected section.

Test results also indicated that a system malfunction causing Halon 1301 concentrations less than those needed to extinguish a fire could produce very high HF levels. Conversely, a deep-seated fire produced relatively small HF levels.

NA-76-22

TEST AND EVALUATION OF THE RADAR PROCESSING SUBSYSTEMS OF THE ALL DIGITAL TRACKING LEVEL SYSTEM

Martin Holtz and Leo Wapelhorst

Interim, March 1977 141 P.

(RD-76-197) (AD A038 624)

This report contains the results of tests that were conducted to determine the performance of the radar processing subsystem of the All Digital Tracking Level System. The measure of performance was based primarily on target detection sensitivity, false target rates in clutter and clutter-free environments, clutter, mapping, and quantizer regulation. The tests consisted of bench tests and tests employing weather clutter samples. Input videos were derived from both an ASR-5 and ASR-7 radar radiating from the National Aviation Facilities Experimental Center (NAFEC) Terminal Facility for Automation and Surveillance Testing (TFAST).

It was concluded that the rank-order quantizer delivered by the contractor did not perform to theoretical expectations. However, the model designed and fabricated by NAFEC was successful in achieving expected results. The second-threshold control function regulated false targets in weather clutter environments to a half order of magnitude of a  $1 \times 10^{-5}$  rate. Target detection

sensitivity was acceptable, but could be improved by utilizing a hardware detector that does not employ a predetector function. Finally, the video select mapping function requires improvement in performance.

NA-76-23

FLIGHT TEST AND EVALUATION OF MDEC (MCDONNELL DOUGLAS ELECTRONICS CORPORATION)  
COLLISION AVOIDANCE SYSTEM

Theodore J. Turnock, Henry Scozzafava, John J. Wojciech and Kent T. Culbertson  
Final, February 1977 274 P.

(RD-75-231) (AD A037 435)

This report covers the test and evaluation of commercial and general aviation versions of airborne collision avoidance system (ACAS) equipments which are candidates for selection in a National Standard Collision Avoidance System. The CAU (collision avoidance unit) and Mini-CAS were evaluated for their communications range, reliability, synchronization, and their ability to provide timely and correct advisories (Tau 2) and maneuver commands (Tau 1). In addition, range and range rate accuracy and display reliability were analyzed. Based on these studies, it is concluded that the CAU and Mini-CAS equipments perform the collision avoidance function as described in ANTC 117. The report also summarizes the operation of the ground and airborne equipment, along with brief descriptions of the aircraft installation, test instrumentation, flight test outline, and the various problems encountered during the evaluation.

NA-76-25

AN INVESTIGATION INTO THE CAPABILITY OF MONITORING A PHASED OPEN-ARRAY ANTENNA

Nicholas J. Talotta

Final, October 1976 53 P.

(RD-76-150) (AD A033 355)

A requirement exists to develop a monitoring capability for air traffic control radar beacon system ground station equipments. The National Aviation Facilities Experimental Center has conducted tests of the Hazeltine open-array antenna to determine if it can be monitored in the electrical near-field of the antenna. Comparison-type data were obtained in the electrical near- and far-field of the antenna. The data indicate that the antenna can be monitored in the near-field.

NA-76-26

AN ANALYSIS OF RADIO NAVIGATION SENSOR ACCURACIES ASSOCIATED WITH AREA  
NAVIGATION (RNAV)

Robert H. Pursel

Interim, February 1977 35 P.

(RD-76-113) (AD A035 619)

Flight test data gathered during a series of RNAV flight tests at the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey, are presented. The report concentrates on the radio navigation sensor errors and the resulting errors in position determination that are inherent in area navigation (RNAV) operation in the terminal area. Statistical data as well as

distributions of the errors are presented. One-standard deviations of 1.5° for very high frequency omnidirectional radio range (VOR) and 0.094 nautical mile for distance measuring equipment (DME) were computed from the flight test data. These statistics represent combined ground and airborne sensor errors.

NA-76-27

NONRIGID BARRIER DESIGN FOR ASSESSMENT OF AUTOMOBILE AGGRESSIVENESS

William M. Perrella, Jr.

Final, September 1976 25 P.

(AD A029 849)

Crash testing of automobiles to improve safety features has been dominated by crash tests against a flat stationary barrier. Such tests do not effectively measure the characteristic known as vehicle aggressiveness. An aggressive automobile may, in the flat barrier impact test, provide a high level of protection for its own occupants. In a two-car collision, such a vehicle may render the survival of the occupants of the other car difficult or impossible to achieve. There are three types of aggressiveness; architectural aggressiveness, such as a very stiff bumper or fender; mass aggressiveness, such as an engine located in such a way that on impact with the struck car it will produce lethal penetration; and structural aggressiveness, where the overall structure of the vehicle is much stiffer than that of the struck car, thus forcing it to absorb most of the crash energy. A moving nonrigid crash barrier was designed to assess vehicle aggressiveness and crash survivability.

NA-76-28

AREA NAVIGATION/VERTICAL AREA NAVIGATION TERMINAL SIMULATION

William Crimbring and John Maurer

Final, March 1977 120 P.

(RD-76-211) (AD A038 623)

A dynamic simulation using the digital simulation facility at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, was conducted to determine the effects on the air traffic control (ATC) system and the system users derivable from the use of area navigation (RNAV) and area navigation with vertical guidance (VNAV) in a high-density terminal area. The John F. Kennedy Airport airspace was configured with an RNAV/VNAV route system to provide the test bed for the study. The study analyzed selected controller workload and system performance measures for various mixtures of RNAV, VNAV, and radar-vectored operations. Results show that controllers can use RNAV/VNAV maneuvers in the control of traffic in lieu of radar vector techniques and that controller workload decreased as the level of RNAV/VNAV participation increased. Controller acceptance of RNAV/VNAV principles and techniques in the ATC terminal area increased as familiarity and experience with RNAV/VNAV were gained. Controllers favored the use of RNAV over a pure radar-vector environment, expressing the opinion that RNAV could provide benefits to both controller and system user. Significant decreases in controller communications workload and slight increases in operations were recorded as the percentages of RNAV/VNAV aircraft in the system were increased. In general, the orderliness of the ATC system improved as the percentage of RNAV/VNAV aircraft was increased. Input from two general aviation trainers (GAT's) was integrated with the targets

from the digital simulation facility. The resultant data provide some insight into minimum avionics requirements for RNAV/VNAV equipment in the terminal area as well as professional pilot opinions concerning RNAV/VNAV ATC procedures, phraseologies, and techniques.

NA-76-30

SIMULATION MODEL FOR AIR TRAFFIC CONTROL COMMUNICATIONS

Robert Mulholland

Final, July 1977 36 P.

(RD-77-69) (AD A044 256)

A computer simulation model designed to mimic second-by-second behavior of air/ground communications in an air traffic control sector is described. The model can be used to simulate any one of nine sector functions (e.g., high-altitude enroute, low-altitude transitional, radar-arrival control, etc.). The model exists as a computer program written in the GPSS V and FORTRAN IV languages. Input variables include aircraft arrival rate into sector, distribution of transmission length, distribution of number of transmissions in an air/ground exchange, etc. Response variables include sector aircraft loading, channel utilization, and communications delay. Model output can be obtained in the form of time series (e.g., minute-by-minute averages of channel utilization) exhibiting the dynamics of sector communications or simple averages of such series taken over several hours of simulated time.

NA-76-31

EVALUATION OF A RED-SILICONE-COATED VISUAL APPROACH SLOPE INDICATOR (VASI) LENS

Raymond E. Johnston

Final, January 1977 15 P.

(RD-76-201) (AD A035 141)

The subject effort was to test and evaluate the results of a new method of producing the red/white color-coded signal used in a Visual Approach Slope Indicator (VASI) system. The present system utilizes a split lens assembly to produce the color coding, which consists of a clear lens segment and a red lens segment, the clear being somewhat smaller than the red, to construct one single VASI lens assembly. A new method of providing the signal was developed by coating the upper part of a circular clear lens with a heat-resistant red-silicone-pigment paint, leaving the lower part clear to transmit the white signal. Laboratory and field tests conducted on it was determined that this method of providing the signal was comparable to the split lens assembly. The results of the tests indicate that this method of producing the signal would be suitable for present and future VASI systems.

NA-76-32

SIMULATION STUDY OF INTERMITTENT POSITIVE CONTROL IN A TERMINAL AREA AIR TRAFFIC CONTROL ENVIRONMENT

S. Rossiter, J. Windle, R. Strack and W. Mullen

Final, January 1977 90 P.

(RD-76-193) (AD A034 902)

A dynamic simulation was conducted to provide an initial and limited investigation into the operational and procedural problems that may exist when intermittent positive control (IPC) is present within a terminal area air traffic control (ATC) system. The simulation was performed at the National Aviation Facilities Experimental Center (NAFEC) and utilized the digital simulation facility (DSF). The test environment simulated a single Discrete Address Beacon System (DABS) sensor site and used the IPC algorithm provided by the MITRE Corporation. The results indicated that the algorithm tested at NAFEC adversely interacted with the present ATC system in a number of operational areas. Rather than remaining passive until required, IPC generated controller alerts and, at times, commands when controllers were following normal procedures and aircraft pairs were well outside ATC separation standards. These unnecessary alerts occurred most frequently between arrivals in the final approach area and between arrivals and departures in those areas where routes crossed. The arrival encounters usually involved high closure rates, and, in general, all encounters demonstrated that a lack of knowledge of ATC intent and a sensitivity to controller technique precipitated the premature IPC activity. Data indicated that significant reductions in the number of IPC messages generated could be achieved by reductions in IPC threshold parameters. Modifications to control procedures could produce similar reductions, but were not considered acceptable because of the tendency toward increased workload and reduced operations rates. As an appendix to this report, a comparative analysis between an airborne collision avoidance system (ACAS) and IPC is provided.

NA-76-35

TEST AND EVALUATION OF AN ENROUTE SYSTEM TERRAIN-AVOIDANCE FUNCTION WITH THE NAS A3d2.1 SYSTEM

Frederick W. Ranger

Interim, February 1977 15 P.

(RD-77-14) (AD A036 441)

This report describes the operational evaluation of an enroute system terrain-avoidance function in conjunction with the National Airspace System Enroute A3d2.1 system. Tests were conducted at the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in a low-altitude environment with simulated digital target data. Tests were designed to evaluate the performance of the terrain-avoidance function with respect to detection capability and adequacy of warning provided. Results indicate that although the terrain-avoidance function performed adequately for most enroute situations, false or late alerts could occur, due to the lag between the terrain-avoidance vector line and true aircraft heading. In most instances, the displayed information could be immediately and correctly interpreted by air traffic controllers and relayed to the pilots in adequate time for a safe response. Several functional changes made to the terrain-avoidance program to prevent problems encountered during testing were not subjected to detailed verification, thereby indicating a need for further testing of the function. Although these problems were encountered, the desirability of having a terrain-avoidance function as part of the enroute National Airspace System was not derogated.

NA-76-36

COMPARISON TESTING OF AN ANALOG AND DIGITAL RANK-ORDER QUANTIZER

Martin H. Holtz

Interim, March 1977 89 P.

(RD-76-212) (AD A038 739)

The Radar Processing Subsystem (RPS) of the All-Digital Tracking Level System was employed to conduct comparative testing of an analog and a digital rank-order quantizer (ROQ). The analog unit was that designed by National Aviation Facilities Experimental Center (NAFEC) to replace an inferior version supplied under contract. The digital ROQ employed an eight-bit analog-to-digital converter and was furnished by the ARTS III contractor. The tests were performed for several system configurations, including two modifications to the digital (ROQ). Performance characteristics were based on percent noise regulation, target detection sensitivity, false target rates, isolated-hit stability, target hit distribution, and video select mapping, as achieved with the RPS. It was concluded that the digital ROQ produced equal to or better system performance, as compared to the analog ROQ provided that the automatic gain control and 50/50 modifications to the digital ROQ were employed.

NA-76-37

SUMMARY OF TRANSPONDER DATA, JUNE 1975 THROUGH AUGUST 1976

George R. Hetrich

Interim June 1977 50 P.

(RD-77-74)

The purpose of this report is to present the results of an evaluation on the performance characteristics of radar beacon transponders used in general aviation aircraft. Data collection was made possible through the utilization of a recently developed transponder performance analyzer. Transponder data samples were obtained over three time periods starting in June 1975 and ending in August 1976. A total of 87 transponders were measured for 9 parameters of operation in June 1975, 56 transponders were measured for 15 parameters of operation from July 1975 through May 1976, and 90 additional transponder samples were obtained during June, July, and August 1976. Data from new off-the-shelf units were compared to data from used transponders. Due to the relatively small data sample, no conclusions could be drawn regarding the overall transponder population, but some trends are evident.



NA-76-38

STRUCTURAL TESTS OF PLASTIC FRANGIBLE COUPLINGS

Bret B. Castle

Final, January 1977 30 P.

(RD-76-202) (AD A035 096)

Tests were conducted on standard frangible couplings and a type of plastic frangible couplings to determine if they were equal to the specified requirements as far as resonant frequency, static loads, and impact loads were concerned. Results indicated that standard metal couplings were congruent with frangibility requirements, but the plastic couplings were not. Under static loads, the plastic units showed excessive bending and, when broken, failed to shear away cleanly. Impact testing indicated that the plastic couplings were much too sinewy to meet the frangibility standards presently required of the standard couplings. Additional considerations in selection of a material for frangible couplings should also include temperature, electrical conductivity, and fatigue factors, none of which were covered in the present test series.

NA-76-39

LONGITUDINAL SEPARATION ANALYSIS OF THE CENTRAL EAST PACIFIC TRACK SYSTEM

Wayne E. Smoot

Final, June 1977 106 P.

(EM-77-3) (AD A044 317)

This report represents an evaluation of aircraft mach number spacing and inertial navigation systems (INS) as regards their impact on longitudinal separation and collision risk in the Central East Pacific (CEP). A nomograph was produced for predicting maximum expected changes in longitudinal separation of aircraft flying with mach number spacing on long-distance transoceanic flights. Results indicate that a statistically significant difference in maintaining longitudinal separation exists between those aircraft employing mach number spacing techniques and those not using the techniques, and likewise between aircraft with more sophisticated air data systems than those without. Collision risk from loss of longitudinal separation was found to be at an acceptable level, both in the old and current CEP systems.

NA-76-40

EVALUATION OF A CORRELATION-SENSITIVE AUTOMATIC CLUTTER ELIMINATOR

William C. Swanseen

Final, March 1977 21 P.

(RD-76-220) (AD A037 125)

A prior computer simulation conducted by MITRE Corporation indicated that an automatic clutter eliminator (ACE) using correlation information within the clutter sum register of the common digitizer (CD) could be used to improve target detection and reduce false targets due to radar weather clutter. Project per-



sonnel at the National Aviation Facilities Experimental Center (NAFEC) designed and fabricated a real time hardware device to perform the correlation estimation and lead edge generation according to the MITRE requirement. A series of tests was conducted to compile data comparing digitizer performance using the correlation-sensitive ACE/CD with performance from an unmodified CD. Test results indicate reductions in false targets up to 30 percent are possible with no loss of real target detection. It was concluded that further field testing of correlated ACE techniques be accomplished to confirm performance under many various radar and weather situations.

NA-76-42

EVALUATION OF A HALON 1301 SYSTEM FOR AIRCRAFT INTERNAL PROTECTION FROM A POSTCRASH EXTERNAL FUEL FIRE

Richard Hill

Final, March 1977 29 P.

(RD-76-218) (AD A039 058)

The use of a Halon 1301 fire-suppression system was evaluated in regard to increasing occupant escape time during a ground crash situation with an external fire adjacent to a cabin opening. Tests were conducted in a DC7 fuselage, varying the exit configurations and external wind conditions. Tests were also conducted using a curtain to compartmentize the cabin, with the Halon 1301 concentration and location of discharge being varied. Smoke, temperature, carbon monoxide, oxygen, and Halon 1301 levels were continuously monitored during the tests at various locations throughout the cabin. Hydrogen fluoride (HF) and hydrogen bromide (HBr) concentrations were obtained by analyzing samples taken from the cabin at various times. The results indicated that the length of protection from flame penetration through an opening was dependent upon external wind conditions. Flame penetration was controlled for up to 3.5 minutes with zero wind, but with a wind of as little as 2 miles per hour (mi/h), the time was reduced to less than 15 seconds. High HF levels were rapidly reached inside the cabin, with concentrations ranging from 60 parts per million (p/m), with no wind, to well over 300 p/m with 2-mi/h wind conditions. Test results also indicated that the use of a curtain to compartmentize the cabin could slow the spread of HF (15 to 20 seconds), but it does not lower the levels reached.

NA-76-43

REEVALUATION OF BURNER CHARACTERISTICS FOR FIRE RESISTANCE TESTS

James E. Demaree

Final, January 1977 41 P.

(RD-76-213) (AD A035 595)

Laboratory evaluations were performed to determine the flame characteristics of the Lennox OB-32 conversion oil burner. Three commercially available burners were modified to produce a flame with characteristics similar to the Lennox OB-32. Various apparatus used in this determination are described in this report. It was concluded that the three burners tested could be modified to

produce flame patterns and characteristics comparable to the Lennox OB-32 conversion oil burner.

The burner described in this report has been used to determine the fire resistance of flexible hose assemblies under simulated conditions. The test was aimed at producing a typical aircraft powerplant fire.

NA-76-44

EVALUATION OF VERY HIGH FREQUENCY INTERFERENCE CANCELLATION SYSTEM  
Charles G. Santora

Final, March 1977 43 P.  
(RD-77-15) (AD A038 850)

This report describes a device to be used at sites, such as remote center air-ground facilities (RCAG's) and Flight Service Stations (FSS's) to counteract the interference due to reception of strong signals from collocated transmitters. The interference cancellation system unit tested handled up to four interfering transmitters and was found to perform as specified and reduce received interfering signals at power levels up to +10 decibels referred to 1 milliwatt (dBm) down to at least -45 dBm.

NA-76-45

SCHOOL BUS FUEL TANK IMPACT TESTS  
Hugo Scheuerman, Roger Young and Maurice Dungan  
Final, December 1976 20 P.  
(NA-76-45)

The objective of these two tests was to investigate school bus fuel tank integrity and to demonstrate whether or not the conditions of a NHTSA proposed moving barrier impact test procedure could be met. It was found that the present location of the fuel tank could be a hazard in a collision and could be protected with minimum additional structure.

NA-76-48

THE EVALUATION OF TWO RANK-ORDER QUANTIZERS AS MODIFICATIONS TO THE COMMON DIGITIZER  
Edward F. Mancus  
Final, July 1977 42 P.  
(RD-77-62) (AD A042 503)

Two rank-order quantizers (ROQ's) were installed in the common digitizer (CD) located at the Elwood, New Jersey, National Aviation Facilities Experimental Center long range radar. Both ROQ's were designed to operate with a radar-transmitted pulse of 2 microseconds. Tests were conducted on the ROQ's and the Improved Quantizers to determine their performance with respect to one another. Test results indicated equivalent reduction in automatic clutter eliminator (ACD) total blank areas when comparing two ROQ's with the Improved Quantizer.

Also, it was concluded that an ROQ employing a guard band around the target tap performed virtually the same as the Improved Quantizer in detecting search targets. The ROQ employing no guard band around the target tap resulted in a reduction in search target detection. It is recommended for future CD procurement that the ROQ be considered as a replacement for the Improved Quantizer because of its design simplicity and reliability.

NA-76-49

NAVAID SUPPORT OF HIGH-ALTITUDE AREA NAVIGATION ROUTES

Arthur G. Halverson and Floyd B. Woodson

Interim, February 1977 122 P.

(RD-76-210) (AD A036 388)

A study was conducted at the National Aviation Facilities Experimental Center (NAFEC) in order to determine the capability of the present system of navigational aids (NAVAID's) to support an area navigation (RNAV) route structure. Coverage contours for each NAVAID were derived through application of radio line-of-sight (LOS) angles from the antenna to the surrounding terrain. A hypothetical high-altitude RNAV structure was tested against the coverage contours of the NAVAID's presently used in the airspace at 18,000 feet and above. Each parent route and its related parallel offsets were checked for areas of excessive route width as well as for areas of noncoverage at a flight altitude 18,000 feet. Based on these results, it is concluded that the present NAVAID system will support a high-altitude RNAV route structure with only minor problems, principally in connection with route widths. But the extent of this problem depends upon air traffic control requirements and the assumed cross-course navigational errors. With definite information regarding these factors, the methodology developed at NAFEC can be effectively used to isolate and identify specific NAVAID coverage problems.

NA-76-50

SLANT AND RUNWAY VISUAL RANGE RELATIONSHIPS

William Lewis and Ernest E. Schlatter

Final, June 1977 31 P.

(RD-77-34) (AD A041 134)

A study was conducted to determine if any significant relationships existed between horizontal and slant visibility during fog conditions. Approximately 11,000 sets of atmospheric transmittance observations in fog were obtained at six horizontal levels from 5 to 155 feet and from the 5- to 155-foot slant path by extinction-type transmissometers mounted on two airfield towers separated by 250 feet. Each observation set was classified into one of seven vertical profile classes according to the transmittance difference between the top (155-foot) and bottom (5-foot) transmissometers. The implications of the various fog structures for aircraft landings are discussed. Average 5- to 155-foot slant visual range versus 5-foot runway visual range (SVR-RVR) ratios and standard deviations of ratios were computed by profile class. An analysis showed that results are definitive and could form the basis of a procedure for estimation SVR from RVR through fog profile measurement. A multiple linear

regression analysis to predict SVR from RVR, surface temperature, windspeed, and atmospheric stability showed RVR to be the best predictor of SVR, while the other variables showed some effect only with dense fog. These results are considered tentative, since they are based on a limited data sample. Fifteen-minute changes in SVR by profile class were examined for certain SVR ranges. Results showed that knowledge of the profile class would not significantly improve 15-minute persistence forecasts of SVR.

NA-76-51

EVALUATION OF RADIO REMOTE CONTROL SYSTEM FOR AIRPORT VISUAL AIDS

Bret B. Castle

Final, June 1977 18 P.

(RD-77-67) (AD A041 603)

An evaluation was made to determine if a particular radio remote control system could provide reliable control of distant airport visual aids in place of laying lengthy control cables to the system's power regulators. Simple operation and flexibility of usage were required of the system, as well as continual monitoring of the status of the remote stations, emergency operation during electrical power failures, and reliability of operation approaching hard-wire systems. Results show that during the 5,000 hours of testing the system worked well, except for high and low operating temperature problems caused by the use of unreliable commercial components in the transceiver. It was recommended that following transceiver improvements, operational evaluation in-service type tests be performed on the system in an operating airport environment.

NA-76-52

FIRE DETECTION, EXTINGUISHMENT, AND MATERIAL TESTS FOR AN AUTOMATED GUIDEWAY TRANSIT VEHICLE

Richard G. Hill and George R. Johnson

Final, November 1977 25 P.

(NA-76-52)

Tests were conducted in a simulated automated guideway transit vehicle to determine the effectivity of a Halon 1301 fire-extinguishing system during various types of fires, evaluate a photoelectric and an ionization fire detection system, and compare various materials under full-scale fire conditions. A portion of a school bus (770 cubic feet) supplied with an airflow system (300 cubic feet per minute--225 recirculated and 75 fresh air) was used as the test article. Smoke density, temperature, carbon monoxide, and Halon 1301 concentrations were monitored throughout the tests. Hydrogen fluoride (HF) samples were taken during the fire extinguishing tests. The noise level associated with the activation of the explosive charge and release of the compressed gas from the 1301 reservoir is high. In the experiment, levels of 120-132 decibel (Absolute) were recorded. There was no attempt to muffle this noise level to the passengers in an enclosed compartment, since this was beyond the scope of the report. A noise suppression system would most likely have to be designed for any practical applications.

Halon 1301 is most effective if it is released within 1 to 2 seconds, to establish the 5 percent by volume concentration. If slower release occurs, or if the fire is deep-seated, the Halon 1301 can be decomposed to HF, a toxic gas. In the tests, when a release time of 7 seconds occurred, the HF concentration reached dangerous conditions. Test results showed that the photoelectric detector was faster responding than the ionization detector. Material tests indicated that underseat fires were more severe than fires on or in the seat for both neoprene and urethane cushions.

NA-76-53

THERMAL DECOMPOSITION PRODUCTS OF AIRCRAFT INTERIOR MATERIALS

Joe C. Spurgeon, Louise C. Speitel and Ray E. Feher

Final, April 1977 52 P.

(RD-77-20) (AD A039 511)

Seventy-five typical aircraft interior materials were thermally decomposed using a combustion tube furnace. A 250-milligram sample was exposed to a temperature of 600° C for 5 minutes while maintaining an airflow rate of 2 liters per minute through the combustion tube. The combustion products were collected in liquid-filled fritted bubblers, and the contents were analyzed for hydrogen cyanide, hydrogen sulfide, hydrogen chloride, hydrogen bromide, and formaldehyde by differential pulse polarography; nitrogen dioxide and sulfur dioxide by visible spectrophotometry; and hydrogen fluoride by potentiometric titration. Carbon monoxide was collected in plastic sample bags and measured by nondispersive infrared analysis. The yields of the nine gases have been reported in terms of milligrams per gram of material. Parametric studies were also conducted to characterize the effects of experimental parameters on gas yields. These parameters include sample weight (250 and 750 mg), percent oxygen (0, 10.5, and 21 percent), airflow rate (1 to 3 lpm), and temperature (400°, 600°, and 800° C).

NA-76-151

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY DENVER TOWER/TRACON

D. Martin

January 1976

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-76-152

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY SEATTLE TOWER/TRACON AND BOEING TOWER

D. Martin

February 1976

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or suggestions, are also encouraged at that time.

NA-76-154

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY DALLAS/FORT WORTH REGIONAL TOWER/TRACON

R. Miller

March 1976

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content, involving modification, revisions and/or additions, are also encouraged at that time.

NA-76-155

TERMINAL FACILITY CONFIGURATION AND DATA SURVEY BAY TRACON AND TOWERS AT SAN FRANCISCO, OAKLAND AND SAN JOSE

Don Martin

April 1976

This document is published by the National Aviation Facilities Experimental Center, Atlantic City, New Jersey, in response to a requirement from Systems Research and Development Service to provide basic data to the sustaining engineering program. It is intended only as a reference source, containing operational information, equipment content, layout, and physical design

characteristics of major terminal facilities. It will be published as a series of facility supplements which will be updated as required during March of each year as long as the information is required for system planners. Changes to the reported conditions, of a nature believed to warrant an errata page, are to be forwarded to NAFEC, attention ANA-260, annually during the month of January. Suggestions on content involving modification, revisions and/or additions, are also encouraged at that time.

NA-76-156

GROUND/AIRBORNE SCENARIOS LOS ANGELES INTERNATIONAL AIRPORT

Lt. Col. John D. Hartnett

May 1976

NA-76-158

GROUND/AIRBORNE SCENARIOS ATLANTA INTERNATIONAL AIRPORT

Lt. Col. John D. Hartnett

July 1976

NA-76-160

AIR TRAFFIC SYSTEMS DIVISION CO-OP PROGRAM 1972 - 1976

John J. Wojciech

NAFEC October 1976 13 P.

(NA-76-160)

Reported herein is a summary of the activities of the Air Traffic Systems Division, ANA-100, Co-op Program over the past 4 years. Student placement procedures, distribution of the students within the division's three engineering branches, and student work activities are discussed. Assignment evaluations obtained from the students and the student evaluations prepared by their supervisors are summarized. Also presented in the report are recommendations for improving the Division Co-op Program and the NAFEC Program as a whole.

Based on the very positive comments from both the co-ops and their supervisors, the ANA-100 Co-op Program has achieved substantial success. This achievement has resulted in more effective accomplishment of current ANA-100 technical activities. Even greater benefits will be derived in the future, since many of the top-quality co-ops are now returning to NAFEC following their graduation.

NA-76-162

IGNITION AND PROPAGATION RATES FOR FLAMES IN A FUEL MIST

C. E. Polymeropoulos and V. Sernas

Final, November 1976 55 P.

(RD-76-31) (AD A034 224)

The droplet size distribution in various experimental air-fuel sprays was measured using a holographic method. There was good agreement between upper-limit log-normal velocity distribution functions and the droplet size data. The Sauter

mean diameter, maximum droplet diameter, and air-fuel ratio were also well represented by the data. Measurements of burning velocities in the sprays tested were satisfactory. Approximate burning velocities in modified fuel sprays produced under wind shear conditions were also calculated.

NA-76-164

GROUND/AIRBORNE SCENARIOS MIAMI INTERNATIONAL AIRPORT

Lt. Col. John D. Hartnett

September 1976

NA-76-165

EVALUATION AND RECOMMENDATIONS FOR SNOWDRIFT CONTROL AT FAA ILS FACILITIES  
BARROW AND DEADHORSE, ALASKA

Darryl J. Calkins

September 1976 41 P.

(RD-76-139) (AD A030 401)

This report describes the existing snowdrifting conditions at the Barrow and Deadhorse airfields and makes recommendations for minimizing the drifting snow at the ILS facilities. The problems of drifting snow at the localizer and glide slope facilities is a result of the structures themselves creating drifts and causing outages. The most economical method of eliminating the problem at the glide slope is relocation of the instrument shelters such that they are not in line with the antenna masts and the prevailing wind direction. The localizer snowdrifts are caused by the bulkiness of the supporting structure carrying the antenna; although it is elevated on piles severe turbulence develops behind the



structure and the snow deposits. Wooden snowfences, 10 ft high, in the parallel rows 200 ft apart will control the snow during an average snow year. If snow fences are ruled out, a new structural design is needed, with minimal cross-sectional area, and widely spaced piles to minimize the buildup. Model studies of each alternative method were carried out to validate the various proposals.

#### NA-77-1

##### A FLIGHT INVESTIGATION OF SYSTEM ACCURACIES AND OPERATIONAL CAPABILITIES OF A GENERAL AVIATION AREA NAVIGATION SYSTEM

Jack D. Edmonds, Robert H. Pursel, and John Gallagher

Final, June 1977 99 P.

(RD-77-43) (AD A042 846)

Flight tests were conducted at the National Aviation Facilities Experimental Center (NAFEC) using a general aviation area navigation (RNAV) system to investigate system accuracies and resultant airspace requirements in the terminal area. Issues investigated were total system error and error budget, flight technical error, turn anticipation, waypoint storage capacity, and results of typical operational maneuvers. Subject pilots for the test represented two distinct levels of experience. Subjects were also restricted to a one-, two-, or three-waypoint storage capacity for various flights. Statistical data are presented for the various error components making up the RNAV total system error. Various operational capabilities were also investigated and graphical data are presented for parallel offsets and turn anticipation. A two standard deviation of  $\pm 1.5$  nmi was measured for total system crosstrack error in the terminal area.

#### NA-77-2

##### ANALYSIS OF SELECTED GENERAL AVIATION STALL/SPIN ACCIDENTS

Jack Shrager

Final, April 1977 90 P.

(RD-77-41) (AD A022 624)

An automated data search of existing general aviation data bases was employed in an effort to relate aircraft stall/spin accident history to general design characteristics. The technique employed utilized a chi-square analysis to evaluate a 9-year stall/spin history of 36 selected aircraft. The statistical analysis indicated that:

1. Accident rates are influenced by aircraft usage.
2. Accident rates are influenced by pilot experience.
3. Low-horsepower low-stallspeed aircraft have a higher propensity to stall/spin accidents.
4. The highest incidence of stall/spin accidents was in the takeoff phase of flight.
5. With the exception of one aircraft type, the chi-square analysis did not identify specific aircraft designs or design categorizations which would have a higher propensity for stall/spin accidents, with all other factors (i.e., pilot experience, aircraft usage) constant.

NA-77-4

HIGH-ALTITUDE AREA NAVIGATION (RNAV) ENROUTE SIMULATION

Francis M. Willett, Jr. and Mark R. Taylor

Final, December 1977 84 P.

(RD-77-128)

A four-part dynamic simulation using two systems of navigation, area navigation (RNAV) and very high frequency omnidirectional radio range (VOR), was conducted using the Digital Simulation Facility (DSF) at the National Aviation Facilities Experimental Center (NAFEC). The objectives were to: (1) validate the results derived from fast-time simulation tests of RNAV and Jet-VOR route structures through real-time simulation tests, (2) determine whether benefits resulted from the application of RNAV in the high-altitude enroute environment, and (3) establish the impact that the number of potential aircraft conflict situations has on the ATC system and system user. Simulations were conducted in a fast-time mode, without controller intervention, for an area encompassed by five high-altitude Chicago Air Route Traffic Control Center (ARTCC) sectors and for a single selected sector of the five. Real-time simulations, with controller intervention, were conducted for both the five- and one-sector configurations. Test results showed that there was a significant reduction in controller workload in the RNAV system compared to the VOR system for both sector configurations, and that correlation was found to exist between the Lincoln Laboratory and NAFEC fast-time simulation potential conflict data. Comparison of the fast-time potential conflict data with real-time controller workload and system performance measures did not show any correlation between the two sets of data. The data from the real-time simulations showed major variations between runs of the same traffic sample, thus precluding the isolation of any possible impact from variations in number of potential conflicts.

NA-77-5

WIND SHEAR: A LITERATURE SEARCH, ANALYSIS, AND ANNOTATED BIBLIOGRAPHY

Jack J. Shrager

Final, February 1977 93 P.

(RD-76-114) (AD A037 310)

A literature search of recent publications (post 1970) on low-altitude wind shear and its relationship to aircraft operations during approach, landing, and takeoff was made. An analysis of the reviewed literature with respect to (1) wind shear characterization/atmospheric modeling, (2) hazard definition/accident analysis, (3) ground-based equipment, (4) airborne equipment, (5) flight test and simulation, (6) forecasting/meteorology, and (7) flight operations/pilot training was made. The analysis of the 216 documents identified by the search are summarized.

NA-77-6

FLIGHT TESTS OF A LOW-COST OMEGA NAVIGATION RECEIVER

Robert Moore

Final, June 1977 75 P.

(RD-77-70)

This report describes flight tests performed: (1) as a preliminary investigation of the feasibility of using low-cost Omega avionics for enroute navigation, and (2) to assess Omega navigation as a supplement to VOR/DME in remote areas. The equipment tested was a prototype Mark III Omega receiver, developed by the Dynell Electronics Corporation, Melville, New York.

Local test flights utilized the Extended area Instrumentation Radar (EAIR) system located at the National Aviation Facilities Experimental Center (NAFEC) as an external position reference, and test flights in Alaska employed a Litton LTN-51 Inertial Navigation System as an onboard position reference.

Results to date indicate: (1) with an adequate antenna, low-cost Omega avionics provides acceptable guidance information during quiescent propagation periods. Flights during diurnal transition periods of the day would require adjustment of preflight computations in order to compensate for anticipated phase changes, resulting in improved destination accuracy at some sacrifice to flightpath linearity, (2) within the state of Alaska, usable Omega navigation signals were received from stations in Norway, Hawaii, North Dakota, and Japan. There were no indications of terrain sensitivity at the minimum enroute altitudes flown.

NA-77-7

EVALUATION OF THOMSON/CSF FIVE-BAY VOR ANTENNA

James G. Dong

Final, October 1977 58 P.

(RD-77-82)

A stacked five-bay VOR antenna was evaluated at the National Aviation Facilities Experimental Center (NAFEC). The antenna was designed for use with a conventional very high frequency omnidirectional radio range (VOR) system to reduce multipath effects by diminishing ground reflections. Tests included airborne and ground measurements to assure operational compatibility of the antenna with FAA transmitting equipment. Measurements were made on the complete array, bays, and antenna elements. Test results indicated that the bearing error was marginal and the large sidelobes caused multipath reflection from nearby obstacles. A computer program used for the analysis of vertical plane radiation patterns in stacked arrays is included.

NA-77-9

SIMULATION OF ORIGINAL AND NAFEC-PROPOSED INTERMITTENT POSITIVE CONTROL COCKPIT DISPLAYS

Donald Eldredge, Warren Crook and Paul Rich

Final, August 1977 35 P.

(RD-77-73)

In order to evaluate the adequacy of aircraft proximity warning and collision avoidance information pilot display, 14 alternative cockpit displays were compared to the original Intermittent Positive Control (IPC) BADCOM display in a subjective evaluation by 17 persons. A single display best incorporating the preferred features was then compared to the BADCOM display in a series of midair collisions simulated in the GAT-2 flight simulator. Twenty-four pilots participated in four test sessions, each with 15 simulated conflicts in each session. Both displays were employed to give IPC maneuver commands and, alternatively, to give proximity warnings without specific maneuver orders. The results from this study indicated that there was no overall significant difference between the two displays evaluated, based on measured pilot performance. However, it was found that the two-altitude sector presentation (NAFEC display) was significantly better than the three altitude sector presentation (BADCOM display) in terms of pilot performance. In addition to the objective evaluation results, the pilots indicated that (a) they preferred the NAFEC display, because of the POSITIVE command approach; and (b) they found the RESUME NAVIGATION command to be important, because it indicated when the threat had passed.

NA-77-10

SIMULATION TESTS OF FLIGHT TECHNICAL ERROR IN 2D/3D AREA NAVIGATION (RNAV) USING A MULTIPLE WAYPOINT RNAV SYSTEM WITH AND WITHOUT A FLIGHT DIRECTOR SYSTEM

Donald Eldredge, Warren G. Crook and William R. Crimbring

Final, October 1977 101 P.

(RD-77-112)

Six pilots participated in a series of flight simulation tests employing solo pilot techniques which were conducted at the National Aviation Facilities Experimental Center (NAFEC) in the cockpit Simulation Facility in order to measure Total System Crosstrack (TSCT) and Flight Technical Error (FTE) using a multiple waypoint storage 2D/3D area navigation (RNAV) system. The tests were designed to assess pilot performance as a function of the interexperimental variables: (1) 2D RNAV mode versus 3D RNAV mode, (2) flight director versus no flight director, (3) insertion of an impromptu waypoint into a previously entered flight plan, and (4) different route structures. Performance was measured on the variables: horizontal tracking, vertical tracking, airspeed control, and procedural performance. Major findings include less TSCT error in the 2D mode, improved tracking accuracy using the flight director, and FTE consistently less than the amount budgeted in AC-90-45A. No statistically significant differences were found for the impromptu waypoint entry; however, one-third of the impromptus resulted in either blunders or procedural errors (including wrong information entered or large overshoots at the waypoint prior to the impromptu segments). Nonprecision approaches were handled quite well with little horizontal error using the RNAV ENROUTE mode; however, navigation signal failures close to the VORTAC caused larger horizontal errors in some

runs. Significant differences in altitude performance were found for 2D RNAV mode versus 3D RNAV mode for climb/descent segments. Significant differences in airspeed control were found for the 2D RNAV mode versus 3D RNAV mode for the climb/descent segments.

NA-77-11

BEACON COLLISION AVOIDANCE SYSTEM (BCAS)-ACTIVE MODE

Maurice Cohen and Charles Richardson

Interim, October 1977 35 P.

(RD-77-98)

This document describes the FAA/MITRE Active Mode of the Beacon Collision Avoidance System (BCAS) through its initial phase. The hardware, its procurement and modification are described; the theory of operation is presented; and the system performance and accuracy during the feasibility flight tests in the NAFEC and Washington, D.C. airspace were discussed. This is a ground-independent, air-to-air system activated by airborne omnidirectional ATCRBS mode C interrogations occurring at a rate of 2 per second. Range and altitude are obtained for each aircraft replying within a 32-nmi radius. Range and altitude rates are computed, and approaching aircraft are tracked. The cockpit CAS display warns the pilot of aircraft crossing with adequate altitude separation and gives a command to climb or dive if the intruding aircraft is at or near the same altitude. Warnings and/or commands are provided 30 seconds before range minimum. System performance was evaluated during test encounters with 400 ft altitude separation. Performance and accuracy analysis is derived from BCAS and ARTS III magnetic tape, and from the tracking phototheodolites over the NAFEC measurement range. Data analysis was performed by the MITRE Corporation. The system in its initial form was not expected to function in high-density areas; however, the system met the initial design goals. Design ideas to distribute the reply population by using multilevel power interrogations have been incorporated in the system for the next phase. This will, hopefully, allow the system to function in the higher density areas. In a later phase, the compatibility of BCAS with DABS will be evaluated.

NA-77-12

INTERMITTENT POSITIVE CONTROL—PHASE I, OPERATIONAL TEST AND EVALUATION

John W. Goodwin

Interim, October 1977 16 P.

(RD-77-125)

This report reflects the results of an effort at the National Aviation Facilities Experimental Center (NAFEC) to test and evaluate the interface between the intermittent positive control (IPC) system and the enroute air traffic controller. In testing this interface, the IPC algorithm was resident in the Digital Simulation Facility, which simulated the operation of a Discrete Address Beacon System (DABS). The test series was operationally oriented and did not consider such factors as program size, loading factors, or processing time. The results of the tests reveal that the IPC controller alerts, consistency of commands, readability of displayed information, and method of displaying information to the controllers were acceptable. The issuance of negative commands to aircraft presents a problem to the

controllers, in that negative phrasiology is not utilized in the air traffic control system. The alerting methods of IPC and conflict alert are similar, but because of the critical timing of the IPC alert, it was felt that a distinctly different alert for IPC should be utilized.

NA-77-13

BOSTON AIR ROUTE TRAFFIC CONTROL CENTER (ARTCC) LIGHTING STUDY

Robert H. Mitchell, Richard L. Sulzer, and Alan J. Kopala

Final, July 1977 34 P.

(RD-77-50)

The purpose of this project was to facilitate the viewing of flight data on plan view displays (PVD's) and the reading of other pertinent data in the ARTCC control room by air traffic controllers. This was accomplished by attenuating distracting light and reflections on the PVD face and increasing the ambient room lighting level. In implementing these objectives, the work consisted of modifying various parts of air traffic control (ATC) equipment in the assigned test area D of the control room. The lighting modifications were evaluated technically by Raytheon and were appraised by a survey, conducted by NAFEC, of the air traffic controllers. The package of modifications was well received by the controllers, but they considered it inadequate and desired more effective improvements. The results of the study indicate that discrete lighting modifications only partially solve the reflection/lighting problem.

NA-77-14

REBUILDING CATHODE RAY TUBES

John W. Aschenbach

Final, October 1977 26 P.

(RD-77-61)

The Federal Aviation Administration (FAA) was engaged in a program to investigate the feasibility of rebuilding large-size cathode ray tubes (CRT's) for emergency requirements. This report is a summary of the results from the evaluation of rebuilt tubes as supplied by several CRT rebuilders. The sample size was not sufficient to conclude that CRT vendors could be qualified to rebuild special CRT's. Perhaps the most useful result of the investigation and testing was the information obtained relative to commercial television CRT improvements to the FAA CRT rebuilding experiments.

NA-77-15

AIR TRAFFIC SEPARATION STUDIES: AN ANNOTATED LISTING OF READING MATERIALS

Paul W. Bradbury

Final, January 1978 120 P.

(EM-77-13)

This bibliographic compilation lists reading materials concerned with separation standards for the air traffic control system. Related subjects, such as collision

risk analysis, navigational track-keeping error, descriptions of proposed navigational systems or aids, and cost/benefit trade-off studies of ATC system design, are included to some extent, but selectively rather than extensively or in depth.

Orientation of the materials selected for listing is largely, but not exclusively, toward oceanic enroute aspects of the international air traffic control systems. The North Atlantic system (NAT) is particularly evident; this follows naturally from the extensive study efforts organized under ICAO as the NAT Systems Planning Troup and the special panel for "Review of the General Concept of Separation (RGSCP)". The style of presentation is tailored to facilitate rapid scan. Annotations are largely derivative from other sources, and the comments are descriptive rather than evaluatory. Comprehensiveness was sacrificed to selectivity to avoid unwieldiness.

NA-77-16

ACCURACY TEST OF AN AIR-TO-AIR RANGING AND BEARING SYSTEM

Vincent J. Luciani

Final, June 1977 21 P.

(RD-77-59)

This report covers the accuracy test of a system designed to measure, display, and record air-to-air range and bearing measurements between in-flight aircraft. Data acquired from flight tests using reference measurements described in the report showed the estimated standard deviation range of error to be 100 feet, reducible to 60 feet via software smoothing of data. The standard deviation of bearing error was  $2.4^\circ$ . It is concluded that the system is well within specifications.

NA-77-17

ALTERNATIVE ENERGY SOURCES FOR FEDERAL AVIATION ADMINISTRATION FACILITIES

Lane G. Hinkley, George C. Apostolakis and Arthur H. Bonello

Final, May 1976 - January 1978 102p.

(RD-78-87)

A literature and industry/government search was made on alternative energy sources. This energy investigation effort concentrated on photovoltaics, wind, fuel cells and thermoelectric/thermionic generators that would produce electrical energy and appeared feasible for use at Federal Aviation Administration (FAA) facilities. As an aid to identify potential FAA facilities where it might be feasible to use an alternative energy system, two questionnaires were received and tabulated.

As a result of this investigation, it was recommended that the FAA proceed to establish alternative energy demonstration sites in order to gain experience in the design, implementation, and operation of such systems. In addition it was recommended that due to the constantly changing and fast advancing nature of energy conversion systems, the FAA should expend some level of effort in continuing the literature/industry/government search initiated under this project in order to remain current on the subject. Also the FAA should establish a centralized data collection and tabulation point for energy requirements/consumption/cost data on a facility basis.



NA-77-18

TWO LIGHTNING-FLASH COUNTER SYSTEMS

L. William Einbinder, Nicholas Mercado, and Robert C. Greenwood

Final, December 1975 - December 1976 42p.

(RD-78-39)

Two lightning-flash counter systems were fabricated at the National Aviation Facilities Experimental Center (NAFEC) to determine local ambient lightning-flash activity and to consider the usefulness of these devices to air traffic control. These two devices were designed by members of two international groups. The first device, CIGRE, is an acronym for "Conference Internationale des Grande Reseaux Electrique." The second device, RSA-10, is an acronym for "Republic of South Africa," a National Electrical Engineering Research Institute and Council for Scientific and industrial Research." Data were collected for about 1 year, and the resultant information indicated that the RSA-10 and the CIGRE lightning-flash counters are effective devices for determining the presence of lightning usually associated with cumulonimbus clouds.

NA-77-20

TERMINAL RADAR INTERFERENCE CRITERIA STUDY

John Kenton

Final, January 1976 - December 1976 81p.

(RD-78-75)

Tests were undertaken to investigate the relationship between pulsed-type interference and the air traffic controller working in the terminal area. This was done by recording a series of pulsed-type interference cases and combining them with simulated analog radar targets to form a set of scenarios for display to a group of Federal Aviation Administration (FAA) controllers. Several operational responses were used as performance measures to investigate interference criteria. The interference cases were then quantified and ordered based on two indexing schemes. Tests based on the indices and the performance measures revealed that correlations exist between the operational responses and the interference cases.

NA-77-21

NEW YORK CITY PILOTS AUTOMATIC TELEPHONE WEATHER ANSWERING SERVICE (PATWAS) TEST, VOLUME II

Frank Staiano and Ephraim Shochet

Final, October 1977 314 P.

(RD-77-80,II)

An improved Pilots Automatic Telephone Weather Answering Service (PATWAS) was subjected to a year-long test in the New York City metropolitan area. The improvements consisted primarily of the following: (1) user access to three route-oriented briefings, (2) an increase on the number of access lines to PATWAS, (3) more frequent updating of information, (4) the addition of special early morning



recordings, (5) capability to request meteorological and aeronautical information from the Weather Message Switching Center for incorporation into the PATWAS message, (6) reduction in the time required for updating, (7) addition of more meteorological and aeronautical information to the PATWAS message, (8) new and more efficient magnetic tape equipment, (9) installation of an acoustic enclosure for PATWAS tape recording, and (10) more efficient organization of the message format.

The purpose of the experiment was to test and evaluate the new PATWAS products, schedules, user acceptance, and the effects on the telephone briefing workload at the flight service station (FSS).

In addition, the test permitted the gathering of technical performance data which could serve as the basis for a new, consolidated national system for the mass dissemination of weather information. It is concluded that the improved PATWAS disseminates more weather information, reduces FAA/NWS telephone briefer workloads, is preferred over the basic PATWAS, and is acceptable to the general aviation public.

NA-77-22

A PRELIMINARY COMPARISON OF THERMAL DECOMPOSITION PRODUCTS OF AIRCRAFT INTERIOR MATERIALS USING THE NATIONAL BUREAU OF STANDARDS SMOKE CHAMBER AND THE COMBUSTION TUBE FURNACE

Louise C. Speitel, Ray E. Feher and Joe C. Spurgeon

Final, March 1978 34 P.

(RD-77-123)

Twelve aircraft interior materials were burned under standard flaming combustion conditions in the National Bureau of Standards (NBS) smoke chamber. Each material was also exposed to 600° Celsius (C) in a combustion tube furnace under conditions of oxidative pyrolysis. The combustion products were collected in liquid-filled impingers, and the contents were analyzed for hydrogen cyanide, hydrogen sulfide, hydrogen chloride, hydrogen bromide, and formaldehyde by differential pulse polarography, nitrogen dioxide and sulfur dioxide by visible spectrophotometry, and hydrogen fluoride by ion-selective electrode. Carbon monoxide was measured directly by a nondispersive infrared analyzer. The yields of the nine gases are reported in terms of milligrams per gram of material. The toxic gas yields were obtained for each material in the NBS smoke chamber and were compared to the yields obtained in the combustion tube furnace. The yields were also compared to those obtained using colorimetric detector tubes in the NBS smoke chamber. The extent of the correlation of the various procedures is reported. The relative yields of HCl, HCN, and H<sub>2</sub>S were found to be somewhat independent of the exposure conditions. The relative yields of the oxidized gases, CO, HCHO, NO<sub>2</sub>, and SO<sub>2</sub>, are much more dependent on the exposure conditions.

NA-77-23

EXECUTIVE SUMMARY: NEW YORK CITY PILOTS AUTOMATIC TELEPHONE WEATHER ANSWERING SERVICE (PATWAS) TEST

Frank Staiano and Ephraim Shocket

Final, October 1977 13 P.

(RD-77-80)

An improved Pilots Automatic Telephone Weather Answering Service (PATWAS) was subjected to a year-long test in the New York City metropolitan area. The improvements consisted primarily of the following: (1) user access to three route-oriented briefings, (2) an increase in the number of access lines to PATWAS, (3) more frequent updating on information, (4) the addition of special early morning recordings, (5) capability to request meteorological and aeronautical information from the Weather Message Switching Center for incorporation into the PATWAS message, (6) reduction in the time required for updating, (7) addition of more meteorological and aeronautical information to the PATWAS message, (8) new and more efficient magnetic tape equipment, (9) installation of an acoustic enclosure for PATWAS tape recording, and (10) more efficient organization of the message format.

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NA-77-26

NEW YORK CITY PILOTS AUTOMATIC TELEPHONE WEATHER ANSWERING SERVICE (PATWAS) TEST, VOLUME I

Frank Staiano and Ephraim Shochet

Final, October 1977 141 P.

(RD-77-80, I)

An improved Pilots Automatic Telephone Weather Answering Service (PATWAS) was subjected to a year-long test in the New York City metropolitan area. The improvements consisted primarily of the following: (1) user access to three route-oriented briefings, (2) an increase in the number of access lines to (PATWAS) (3) more frequent updating of information, (4) the addition of special early morning recordings, (5) capability to request meteorological and aeronautical information from the Weather Message Switching Center for incorporation into the PATWAS message, (6) reduction in the time required for updating, (7) addition of more meteorological and aeronautical information to the PATWAS message, (8) new and more efficient magnetic tape equipment, (9) installation of an acoustic enclosure for PATWAS tape recording, and (10) more efficient organization of the message format.

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NA-77-27

#### LAS VEGAS GRAPHIC STUDY

John J. Maurer, Victor J Misiewicz and Robert W. Tack  
Final, January 1978 126 P.  
(RD-77-182)

A graphic study was conducted by the National Aviation Facilities Experimental Center (NAFEC) to develop and evaluate a number of new procedural plans for the control of air traffic operating within the Las Vegas terminal area. A plan was also developed for a "head-on" type departure/arrival operation for Nellis Air Force Base (AFB). A controller opinion questionnaire was developed around factors that comprise elements of air traffic control that take into consideration the users, controllers, and the area. Each plan was evaluated by a panel of 14 air traffic control specialists. The new plans for the terminal area, along with the present operation procedures, were evaluated for each of four directions of operation or runway configurations and then statistically compared with each other. The "head-on" plan for Nellis AFB was likewise evaluated, and results from the questionnaires statistically compared with present operation procedures at Nellis AFB. The results of the evaluation indicate that, overall, plans 1 and 2 were significantly preferred over the present system and plan 2 was also significantly preferred over plan 2 (Head-On Procedures). Basic reasons for the raters' choice of the Nellis present system over the head-on procedure were safety, complexity of operation, controller workload, and adverse effects to missions at Nellis due to delays.

NA-77-28

#### DERIVATION OF GROUNDSPED INFORMATION FROM AIRBORNE DISTANCE MEASURING EQUIPMENT (DME) INTERROGATORS

John Gallagher, William Lynn and Robert H. Pursel  
Final, November 1977 67 P.  
(RD-77-135)

Laboratory and flight tests were conducted to investigate the derivation of aircraft groundspeed from the range rate pulse information obtained from ARINC 568 distance measuring equipment (DME) interrogators. Initial tests determined the limitation of the range rate pulse output from the two interrogators tested. Subsequent effort was directed toward digital filtering techniques to improve

accuracy and response time of the DME-derived groundspeed. Best results were obtained with either accelerometer complementation or Kalman filtering with velocity and acceleration observations. Both techniques achieved standard deviations of about 3 knots when compared to Inertial Navigation System (INS) groundspeed.

NA-77-29

TEST AND EVALUATION OF THE MOVING TARGET DETECTOR (MTD) RADAR  
Ronald S. Bassford, William Goodchild and Alfred De La Marche  
Final, October 1977 123 P.  
(RD-77-118)

The moving target detector (MTD) terminal radar processor system was evaluated to determine its capability to provide radar data suitable for utilization by the Automated Radar Terminal System.

The major objective of testing was to compare the target detection in clutter performance of the MTD system with that of the best terminal radar processor system in the FAA inventory. The comparative tests were conducted using test signals and flight test aircraft. The test signals were used to determine false alarm rates, probability of detection, accuracy, velocity response, and subclutter visibility capabilities. Flight testing was performed to determine subclutter visibility, subweather visibility, and target resolution capabilities.

Additional tests were performed to determine the compatibility of the MTD processor with terminal radar systems currently in use in the Federal Aviation Administration (FAA).

The results of the tests demonstrated that the MTD system capability to detect targets in a clutter environment was much better than that of present FAA systems. It effectively eliminated all clutter experienced in the National Aviation Facilities Experimental Center (NAFEC) radar environment. The MTD processor is compatible with present FAA radar systems.

NA-77-30

STUDY OF NAVAIDS REMOTE PERFORMANCE CONTROL AND DISPLAY  
Morris Ritter, Jack Bernstein, Ronald Polillo, Carmen Munafo, James L. D'Ottavi,  
and Matthew Naimo.  
Final, April 1977 54P.

This study paralleling FAA's Maintenance Growth Management concepts presents a standardized and modularized approach for the remoting of certification type data for multiple NAVAIDS (VOR, TACAN, ILS, etc.) to provide ATF status and control at a central location. Growth potential to encompass other NAVAID types (RCAG, ALS, RVR, Beacon/Radar, etc.) may be incorporated in the proposed system, providing the proper interfaces are accomplished.

NA-77-32

COLLISION RISK AND ECONOMIC BENEFIT ANALYSIS OF COMPOSITE SEPARATION FOR THE  
CENTRAL EAST PACIFIC TRACK SYSTEM

Allen C. Busch, Brian Colamosca and John R. Vander Veer

Final, June 1977 141 P.

(EM-77-5)

This report presents an evaluation of the application of composite separation to the Central East Pacific (CEP) track system. Criteria for the evaluation were a collision risk and an economic benefit's comparison of the existing four-route and proposed composite six-route systems. A 6-month data collection was performed. Radar data from land-based facilities in California and Hawaii and from Ocean Station Vessel November were processed to determine aircraft navigation performance. Utilization of the existing system was gauged from air traffic control facility data, and flight crew survey forms were used to collect information necessary for comparative analysis purposes. The report describes estimation of collision risk model parameters from the data. Lateral, longitudinal, and composite collision risks were estimated for the existing and proposed composite systems based upon accepted North Atlantic Systems planning Group (NAT/SPG) methodology, while vertical collision risk was calculated based upon previous NAT/SPG studies. Lateral collision risk for the proposed composite system was found to be lower than for the existing structure. Comparisons of fuel burn and flight times indicated that the proposed composite system would be more economically beneficial than the existing route configuration. As a result of the study, the proposed composite system was recommended for implementation on a trial basis.

NA-77-33

FEASIBILITY STUDY FOR SIMULATION OF AN AIRPORT TOWER CONTROL ENVIRONMENT

Dr. Helen W. Hamilton

Final, February 1978 80 P.

(RD-77-190)

The feasibility and desirability of developing an airport tower control simulation training facility at the FAA Academy was investigated. Training program needs were assessed, and the state-of-the-art in simulation technology was surveyed. Several large-scale airport tower and ship's bridge simulators are described and evaluated from an operational and engineering viewpoint; also, a number of flight simulators and image generation and projection systems are considered with regard to the applicability of the concepts to the FAA training requirements. Computer-generated image systems versus other imaging technologies are discussed with reference to realism requirements, capability for efficient generation of instructional materials, and for objective student evaluation. The large number of visual-scene simulation facilities presently in use or under contract development for a wide variety of uses indicates that tower control application is entirely feasible.

NA-77-34

EXPERIMENTAL SCALING OF MODIFIED FUEL BREAKUP

Thor I. Eklund

Interim, August 1977 24 P.

(RD-77-114)

A small-scale test configuration was developed for modified fuel breakup and ignition testing. The configuration consisted of a 1/4-inch fuel delivery tube within a 1-inch air atomization pipe followed by a deceleration cone. Photographic evaluation required design of a unique fuel spray photographic chamber which has the capability of photomicrographic, schlieren, and stroboscopic photographic techniques. The chamber employs positive pressurization with diluent air to prevent spray recirculation and fuel deposition on optical components. The spark photographs proved that the breakup phenomenon can be scaled down without obliteration of the dominant rheological effects. Motion pictures of ignition show the same flammability behavior shown in larger scale tests. It is concluded that the concentric tube atomization technique provides a practical method for comparative evaluation of modified fuels on a small scale.

NA-77-35

FULL-SCALE AIRCRAFT CRASH TESTS OF MODIFIED JET FUEL

Robert H. Ahlers

Final, July 1977 97 P.

(RD-77-13)

Crash tests were conducted with two A3 and two RB66 aircraft under impact-survivable crash conditions. The wing tanks in the first RB66 aircraft contained Jet A fuel modified with an 0.7-percent polymeric additive. The aircraft was crash tested into the specially constructed test site at 104.6 knots. The fuel mist generated by the fuel released from four crash-inflicted openings in the front wing spar was not ignited by the array of ignition sources. The wing tanks in the second RB66 aircraft were filled with JET A fuel modified with 0.5-percent of the same polymeric additive. The aircraft was crashed into the test site at 102.4 knots. The test conditions for the second RB66 test were made more severe by increasing the fuel temperature, partially drilling out areas in the front spar to increase the opened fuel spillage area, and by adding four fuel release openings under the wing, larger ignition sources, and operating the engines. The fuel mist burst into flame and followed the aircraft down the test site, continuing to burn until extinguished by the fire-fighting crew. These full-scale tests indicate that modified fuels have a potential for reducing the postcrash fire hazard and that small-scale tests should be conducted which are representative of full-scale crash conditions to determine the additive concentration to be used in any future crash tests.

NA-77-36

SIMULATOR PILOT CONSOLES FOR NAS ENROUTE AND ARTS III FACILITIES

Kenneth House, Stephen Karovic and Theodore Rundall

Final, November 1977 104 P.

(RD-77-136)

This report describes the work effort and results of a feasibility and desirability study of replacing simulator pilot consoles in the field with more cost effective, easier to learn and use devices. Technically, such an action was found to be feasible and could result in a significantly improved simulator pilot operating capability. A touch panel input device using a menu list concept with target to map association, performed by an interface processor, is recommended. As an aid to deciding the desirability of proceeding with such a procurement, the costs of various alternatives were estimated. The cost of the preferred system was found to exceed the budget, unless a reduced number of consoles or sites were in which case the average cost per console was increased substantially. The information from field input was logically analyzed to arrive at the conclusion that the limited life potential of the system, the operational limits on increased training, and high overall cost make the desirability of the action questionable.

NA-77-37

SATELLITE COMMUNICATIONS MODE SIMULATION TESTS FOR OCEANIC AIR TRAFFIC CONTROL

Francis W. Jefferson

Final, March 1978 58 P.

(RD-77-187)

Tests of simulated satellite system configurations and channel access control were conducted with air traffic control (ATC) test subjects to determine controller reaction to the satellite mode of communications and their interaction with associated input/output interfaces.

The tests were designed to simulate an oceanic ATC environment supported by satellite communications and surveillance. Traffic scenarios were simulated through use of prepared flight plans and communications scripts and use of a simulated aircraft terminal. Communications delays were introduced into the tests to approximate those delays that may be encountered during actual satellite-supported ATC operations. Data were acquired for the controller test subjects reaction to different voice and data communications delay/restriction situations, voice channel queuing, data communications message length and format constraints, acceptance of required communications disciplines, and the mix of voice and data communications when there was a choice between the two methods of communication.

Results were: (1) Controller test subjects favored using data communications to accomplish routine controller-to-pilot communications transactions and voice communication to resolve difficult traffic control situations, (2) actual data from the test logs corroborated test subjects' stated preference, and (3) controller test subjects tended to adapt their communications procedure options to be compatible with the communications system disciplines.



NA-77-38

GENERAL AVIATION (FAR 23) COCKPIT STANDARDIZATION ANALYSIS

Robert J. Ontiveros, Roman M. Spangler and Richard L. Sulzer

Final, March 1978 115 P.

(RD-77-192)

Cockpit design features amenable to standardization in small general aviation aircraft were studied with the goal of increasing safety. A list of 101 cockpit design features was presented to 82 experienced pilots who indicated where they believed increased standardization was warranted. Features cited by half or more of the pilots were studied further and reduced to nine design areas considered to warrant near-term action. Selection of these areas was based on analysis of accident reports and practicality considerations in addition to pilot comments. Three of the design areas relate to the cockpit functions of housing and protection the pilot (improved body restraint system, more positive action and positive latching of adjustable pilot seats, and door latching with a visible locked state). The remaining six areas relate to the other major cockpit function of providing the man-machine interface required to operate the aircraft (fuel management system, powerplant controls, flight instruments, powerplant instruments, instrument lighting, and electrical circuit breakers). Separate sections of the report summarize the data assembled to justify the recommendation for standardization actions in each of the nine areas.

NA-77-39

TEST AND EVALUATION OF AIR/GROUND COMMUNICATIONS ANTENNAS

James J. Coyle

Final, January - December 1977 123p.

(NA-77-39)

This report presents data from the evaluation and analysis of a select group of very high frequency (VHF) and ultrahigh frequency (UHF) Air/Ground (A/G) communication antennas. Antenna patterns, gain, and voltage standing wave ratio measurements were made at the National Aviation Facilities Experimental Center (NAFEC) antenna range on both Federal Aviation Administration (FAA) specified and commercially available off-the-shelf antennas. These antenna data show that improved A/G communications coverage can be obtained with some of the commercially available antennas.

NA-77-40

EMISSION SAMPLE PROBE INVESTIGATION OF A MIXED FLOW JT8D-11 TURBOFAN ENGINE

Gerald R. Slusher

Final, January 1973 - June 1977 60p.

(RD-77-175)

An investigation of the emissions on the exhaust plume of a mixed flow JT-D-11 turbofan engine was conducted in order to optimize the shape, size, and location of fixed probes for acquiring representative emission samples. Traverse of



177 points over the exhaust nozzle were accomplished on a 2-inch-square grid. The average emission levels, contours, and profile distributions were determined. The predicted performance of area weighted cruciform and diamond probe designs were calculated from interpolations of the traverse contours. Exhaust emissions were measured with: (1) five mixing cruciform probes, (2) multihole averaging probes in the core, and (3) the engine turbine discharge pressure probes. Detailed traverses across engine power are considered necessary for representative emission measurement because of limitations existing in all fixed probing techniques investigated.

NA-77-41

THE ANALYSIS OF NATIONAL TRANSPORTATION SAFETY BOARD LARGE FIXED-WING AIRCRAFT ACCIDENT/INCIDENT REPORTS FOR THE POTENTIAL PRESENCE OF LOW-LEVEL WIND SHEAR

Jack J. Shrager

Final, December 1977 82p.

(RD-77-169)

The National Transportation Safety Board aircraft accident/incident data base covering the years 1964 through 1975 was screened to select those accidents involving aircraft of 12,500 pounds gross weight or greater in which the potential of low-level wind shear as a factor could not be discounted. The successive filtering techniques employed eliminated all but 25 of the 59,465 accidents or incidents which comprised the total data base used. The presence of a low-level wind shear was a distinct possibility in these 25 takeoff or approach and landing accidents/incidents.

NA-77-42

HEAD-UP DISPLAYS: A LITERATURE REVIEW AND ANALYSIS WITH AN ANNOTATED BIBLIOGRAPHY

Jack J. Shrager

Final, October 1976 - September 1977 134p.

(RD-78-31)

This report is, in part, a bibliographic compilation of 293 publications relating to head-up displays (HUD's) for aircraft cockpit application and a summary of an evaluation of their contents in the areas of human factors, optical techniques, symbology, system concept, safety, simulation and flight test, and other factors or applications. The objective of this in-depth literature review is to determine the appropriate follow-up course of action in HUD's as it relates to civil aircraft analysis which was also performed simultaneously is also summarised. It indicated that a HUD for the next generation can offer not only (1) resolution of illusionary problems, (2) reduction in pilot workload, (3) standardized cockpit procedures for both IFR and VFR operation, (4) reduction in intercrew dependency and coordination, but also has the potential for (5) terrain avoidance during takeoff and landing, (6) collision avoidance both in-flight and during ground operations, (7) taxi and takeoff clearance and conformation, (8) clearance delivery, (9) weather advisories, (10) efficient energy management and fuel economy, (11) noise abatement guidance, (12) prioritized annunciating and altering, and (13) pseudo-INS capability.

NA-77-43

DEVELOPMENT OF VOCABULARY FOR DEMONSTRATION OF SPEECH CONCATENATION SYSTEM  
Ephraim Shochet  
Interim, March 1978 49p.  
(RD-77-164)

The purpose of this report is to document the development of a full and comprehensive vocabulary of words and phrases (predominately phrases), derived by message analysis of a large sample of verbal output from the New York City Pilots Automatic Telephone Weather Answering Service (PATWAS). This vocabulary is developed to test and evaluate the capability of disseminating PATWAS messages by a prototype speech concatenation system being developed at the National Aviation Facilities Experimental Center (NAFEC). One of the key objectives of the prototype model is to demonstrate the capability of dissemination PATWAS messages by the method of automatic message composition. It is apparent that recently developed digital techniques can enhance the achievement and acceptability of word-concatenated speech, and thus present a future possibility of producing spoken weather reports, and other valuable communication services. A necessary step in the vocabulary preparation phase is the development of a corpus of utterances that represent the linguistic domain for PATWAS messages. This corpus of utterances, entitled "Vocabulary for Demonstration of Speech Concatenation System" is contained in this report. In general, the aim is to provide a full and comprehensive vocabulary designed to include: (1) a message introduction, (2) a winds aloft forecast, (3) hourly observations, (4) flight precautions, (5) synopsis reports, (6) terminal forecasts, (7) route forecasts, and (8) Notices to Airmen (NOTAM's) on a route-oriented basis. The vocabulary as contained in this report will be subject to test and evaluation with the objective of reducing the vocabulary size to the point where it is neither greater than nor less than what is required.

NA-77-44

INTERFERENCE IN COMMUNICATIONS AND NAVIGATION AVIONICS FROM COMMERCIAL FM STATIONS  
Edward M. Sawtelle and James G. Dong  
Final, December 1976 - November 1977 275p.  
(RD-78-35)

The effects of commercial frequency modulation (FM) broadcast stations on communications and navigation avionics were investigated employing several classes of avionics receivers. Flight tests were completed employing site frequencies with intermodulation interference determined by a computer program culling for possible intermodulation products in selected midwestern and southern states. Laboratory measurements were accomplished on the receivers and antenna pattern measurements of typical aircraft antennas were obtained to determine the areas that improvements can best be applied to alleviate the FM interference problem. Results indicate that a 10 dB increase in rejection of FM signals in avionic receivers would eliminate most FM interferences. Included is a proposed method utilizing the Venn diagram approach for predicting possible FM interference assignments under consideration. It is recommended that a flight test program be established to determine FM spectrum signatures and power levels at airports.

NA-77-45

AN ANALYSIS OF RADIO NAVIGATION SENSOR ACCURACIES ASSOCIATED WITH AREA NAVIGATION (RNAV)

Thomas V. Logue

Final September 1974 - September 1976 83p.

(RD-78-85)

Flight test data gathered during a series of RNAV flight tests at the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey, are presented. The report concentrates on the radio navigation sensor errors and the resulting errors in position determination that are inherent in area navigation (RNAV) operation in the terminal area. Statistical data, as well as distributions of the errors, are presented. Also included is a comparison of the Advisory Circular 90-45A tangent point table calculated from regression equations. One standard deviation of 1.4 nautical miles for very high frequency omnidirectional radio range (VOR) and 0.11 nautical mile for distance measuring equipment (DME) were computed from the flight test data. These statistics represent combined ground and airborne sensor errors.

NA-77-47

EVALUATION OF A 100-WATT ELEVATED HIGH-INTENSITY RUNWAY EDGE LIGHT

Raymond E. Johnston and E. Leon Reamer

Final, March 1978 20 P.

(RD-77-176)

The purpose of this project is to evaluate a newly designed, elevated, high-intensity runway edge light using a 100-watt lamp as its light source, rather than the standard 200-watt lamp, to determine if the lower wattage lamp and fixture combination would be satisfactory for category I and category II low-visibility operations, where a Federal Aviation Administration Specification type L-862 runway edge light fixture would be required. Pilot opinion during flight tests indicates that an installed group A version of the experimental runway edge light unit is visually adequate for category I weather operations and should be adequate for category II operations. Group A lights, however, did not meet the Office of Airport Programs Specification for L-862 runway edge lights (Advisory Circular 150/5345-48). An improved group B version will meet both requirements, since it satisfactorily passed the L-862 photometric specifications. This is the final report of a series that includes the following two interim reports: (1) FAA-RD-74-128, "Evaluation of an Experimental Elevated High-Intensity Runway Edge Light," and (2) FAA-RD-74-171, "Evaluation of an Experimental High-Intensity Inset Runway Edge Light Fixture."

NA-77-48

TESTS OF CRASH-RESISTANT FUEL SYSTEM FOR GENERAL AVIATION

William M. Perrella, Jr.

Interim, March 1978 46p.

(RD-78-28)

A significant percentage of general aviation aircraft accidents result in post-crash fires due to the ignition of fuel spillage, often contributing injury or death to the aircraft occupants.

Testing was performed to demonstrate the performance of light-weight, flexible, crash-resistant fuel cells combined with the use of frangible fuel line couplings. Included in these tests were three full-scale crash tests of a typical light twin aircraft. In all of these tests, the crash-resistant fuel system performed satisfactorily.

NA-77-49

AN EVALUATION OF MODIFIED RNAV TERMINAL PROCEDURES USING A SINGLE-WAYPOINT RNAV SYSTEM

Donald Eldredge, Bernard Goldberg, and William Crimbring  
Final, April 1978 120 P.  
(RD-78-27)

Nine pilots participated in a series of flight simulation tests employing solo pilot techniques which were conducted at the National Aviation Facilities Experimental Center (NAFEC) in order to measure Total System Crosstrack (TSCT) and Flight Technical Error (FTE) using a single-waypoint area navigation (RNAV) system. The tests were designed to assess pilot performance as a function of routes and route structures (consisting of different combinations of waypoints and/or intersections). Performance was measured on the variables: horizontal tracking and procedural performance. The horizontal tracking data included both steady state and transition data. The major findings of this study were: (1) that 10 of the 14 intersections exhibited more variability during transitions than did the corresponding waypoints, (2) the RMS TSCT and FTE steady state statistical data produced no significant trends among the combinations of nine route/route structures, (3) procedural performance (accuracy of data inputs) was affected by the route/route structure combinations, and pilot comments indicated that the design of the RNAV head and its placement in the procedural instrument panel were contributing factors to procedural performance, (4) the procedural requirement for a two-waypoint terminal RNAV instrument procedure which defines the final approach course is valid, (5) an intersection should not be used for an initial approach fix, and (6) distance to waypoint (DTW) fixes should be designated in lieu of waypoints whenever the distance between fixes is less than 5.0 nautical miles (nmi) and the DTW fix is not a turn point. Primarily, DTW fixes should be used for altitude restrictions on final approach.

NA-77-152

BOEING 707-300 LEAST RISK BOMB LOCATION STUDY

Paul Brault, Bill Hurlin, Jag Hajari and Larry Roseburg  
Final, April 1977 46 P.  
(RD-76-168)

This report covers an analytical study to determine the least risk location on 707-300 airplane for positioning a discovered explosive device. The study consisted of (1) a review of existing methods of predicting blast effects on typical aircraft structure, (2) selecting candidate locations, (3) determining the aircraft's capability for continued safe flight with minimum and maximum damage at the candidate locations, and (4) developing procedures which would provide the best chance of a safe landing in the event of detonation. The study concludes that a location on the fuselage of the aft main entry door would be the least risk location, that the wing center section fuel tank would be penetrated at the forward emergency escape hatch location and that maximum damage at the Sta 1060 location would exceed the residual strength of the structure.

NA-77-153

GROUND/AIRBORNE SCENARIOS SAN FRANCISCO INTERNATIONAL AIRPORT

Lt. Col. John D. Hartnett

December 1976

NA-77-174

THE O'HARE TRACON MOCK-UP STUDY

Don Martin

April 1977

This report has been prepared to acquaint systems planners with the procedure for participation, methodology for accomplishment and the potential value of NAFEC's terminal sustaining engineering program in the sub-category of

facility mockup activities. Copies of appropriate correspondence are supplemented by intentionally limited narrative content and comment and by extensive photographic documentation through the "start to finish" span of an exemplary effort: the Chicago TRACON design study. It supplements NAFEC's letter report, NA-76-61-LR, "Chicago O'Hare TRACON study" which is enclosed as appendix A.

NA-77-179

TIME DEGRADATION FACTORS FOR TURBINE ENGINE EXHAUST EMISSIONS, VOLUME I -  
PROGRAM DESCRIPTION AND RESULTS

Marvin Platt and I. R. Norster

Interim, August 1974 - June 1977 146p.

(RD-78-56, I - VIII)

This is the first volume of an eight-volume interim report which documents the test data obtained in a study of turbine emission degradation. This volume contains an introduction to the program, a description of the test schedule, equipment, procedures, and data processing techniques, as well as a discussion of the test data itself. A total of 519 repetitious emission tests were conducted over a period of 22 months on units of the following engine types: JT8D-9, JT8D-7, JT3D-7, JT3D-3B, JT9D-3A, RB211-22B, and CF700-2D. Emissions of CO<sub>2</sub>, CO, HC, NO, NO<sub>x</sub>, and smoke were monitored, in addition to various engine operation parameters, over an eight-mode test cycle ranging from cold idle to take-off and back to hot idle. Test data in volumes II - VIII on microfiche in back pocket of volume I.

NA-77-180

STUDIES OF THE FLASH FIRE POTENTIAL OF AIRCRAFT CABIN INTERIOR MATERIALS

Michael J. Manka, Henry Pierce, and Clayton Huggett

Final, December 1977 37 P.

(RD-77-47)

This is the third in a series of reports describing work carried out under the joint sponsorship of the National Bureau of Standards (NBS) and the Federal Aviation Administration (FAA) to develop a method of assessing the flash fire potential of materials found in aircraft cabin interiors.

The flash fire cell described in the previous report was modified further and used to evaluate the flash fire potential of a series of 24 typical aircraft cabin interior materials. Flash fires were observed in the apparatus at fuel loadings as low as 0.23 g/L.

A minimum energy principle was proposed to characterize the flash fire behavior of the complex mixture of fuels derived from the pyrolysis of organic materials. This principle states that a flash fire is possible when the potential combustion energy content of the pyrolyzate-air mixture exceeds approximately 425 cal/L.

A variety of experiments was performed to provide support for the minimum energy principle. The results were in general agreement with predictions, but the accuracy of the measurements was not good enough to permit detailed conclusions.

Oxidative pyrolysis plays a significant role in the formation of the fuel-air mixture in the flash fire cell. Particulates contribute to the creation of flash fire conditions, but they present a difficult measurement problem.

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